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ABSTRACT

This document offers science teachers a reference for various student projects that are intended to increase student interest in engineering, science, and technology. The book contains information, guidelines, and specific ideas for: (1) engineering design competitions; (2) engineering problem solving competitions; and (3) short-term mini-projects. The engineering design competitions emphasize team participation in the design, building, and testing of workable projects in a competitive atmosphere. Included in this section are design parameters, the materials limitations, and the testing and scoring procedures. The engineering problem solving section empahsizes the "pen and paper" approach to the technical, economic and social aspects of engineering problems. These competitions stress the use of research, investigation, decision-making and communication skills. The mini-projects are designed to be completed during a two-hour session and can be set up in a competition manner also. Sample problem solutions are included. (TW)

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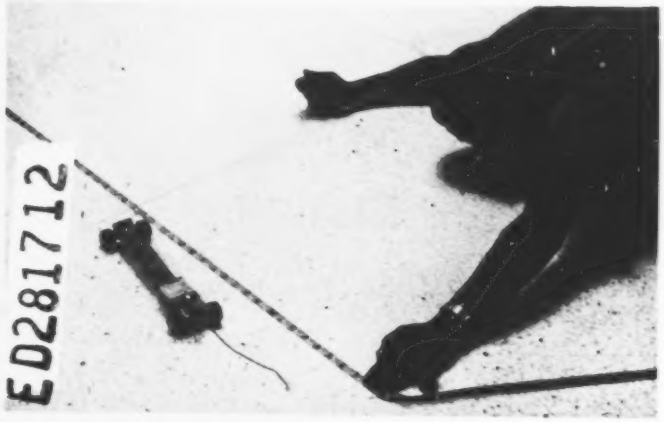

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NOTE

All dimensions and measurements in this guide are in metric except where the commercially accepted standard dictates otherwise, e.g. 1/4-inch plywood, 8-1/2 x 11-inch paper (standard lettersize), etc. All abbreviations are in accordance with the American National Standards Institute Standards for Abbreviations.

The world of engineering, technology and science can be explored through JETS. Students interested in these fields enjoy the opportunity to develop their math skills, apply their scientific knowledge and sharpen their communication skills through JETS activities. These experiences may formulate career objectives for some. For others, it may provide the opportunity to explore science and technology more comprehensively than before.

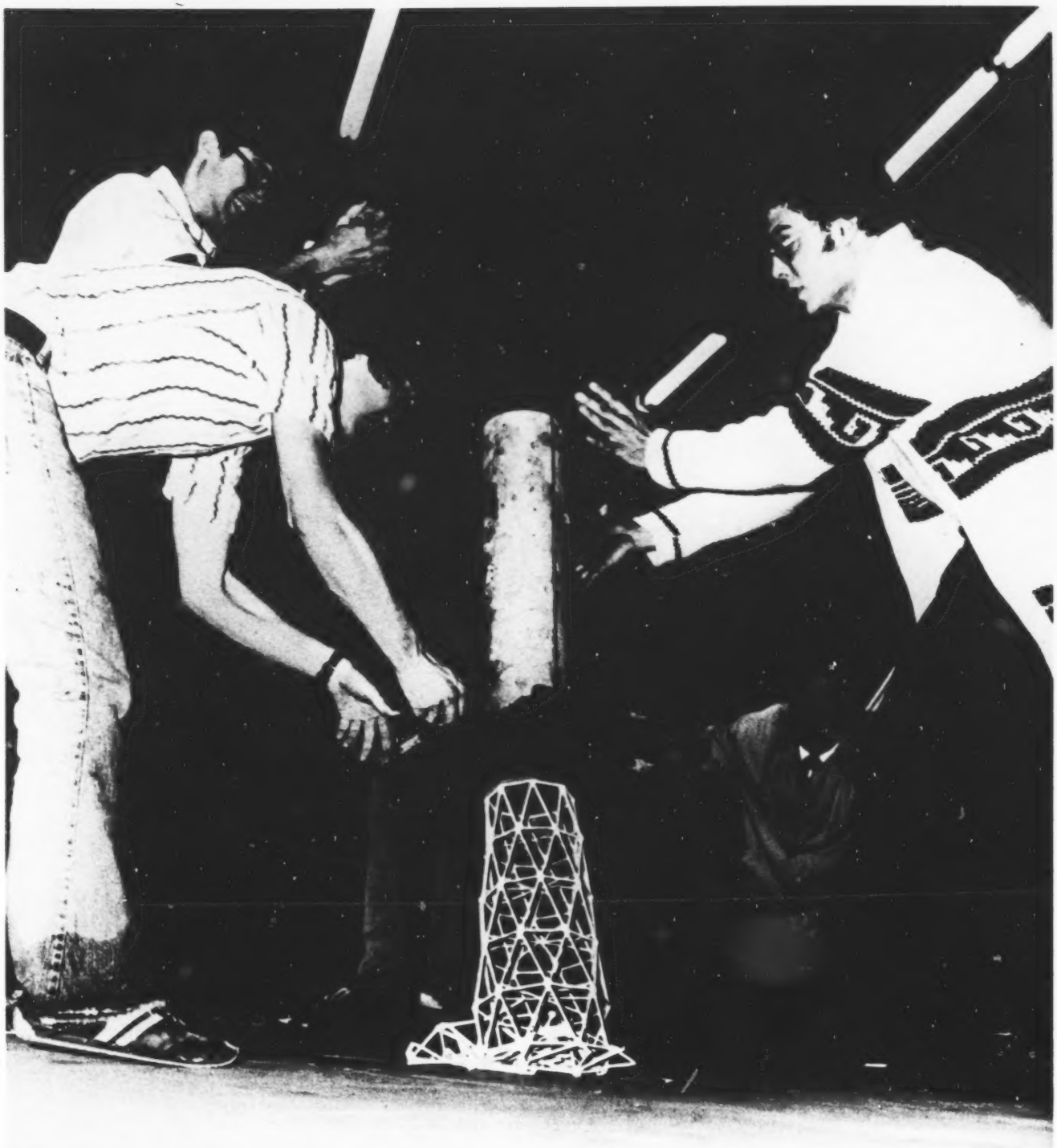
Program Aids was developed to assist local JETS Chapters in planning interesting competitions, projects and meetings. Some of these activities are designed for individual participation but most are designed for teams of two or more. Some of the activities are designed for enjoyment. Some of the activities require research. Some of the activities require construction. All of the activities are designed to promote engineering skills.

The Engineering Design Competitions emphasize team participation in the design, building and testing of workable project models in a competitive atmosphere. These competitions stress creativity and ingenuity as well as an understanding of engineering principles. Included in this section is the information necessary for the development of a project--the design parameters, the materials limitations, and the testing and scoring procedures. These activities are suitable for intrachapter or interchapter competitions.

The Engineering Problem Solving Competitions emphasize the "pen and paper" approach to the technical, economic and social aspects of engineering problems. These competitions stress the use of research, investigation, technology assessment, objective decision-making and communication skills. Technical papers and technical reports with oral presentations simulate the role of the practicing engineer. It also offers the opportunity to investigate the various disciplines within the engineering profession as well as to explore new areas of technology. These activities are suitable for intrachapter and interchapter competitions.

The Miniprojects are short-term projects that are appropriate for Chapter meeting activities and intrachapter competitions. These projects include discussion ideas, design problems and problem solving techniques. These activities were designed to be completed within two hours and stress creativity, innovation and technological literacy. Many of these activities may be expanded to interchapter competitions.

The utilization of **Program Aids** for local JETS chapters is encouraged. These materials should be used in conjunction with the **JETS Chapter Handbook** and **Engineering Career Aids** for the organization and planning of JETS activities.



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Engineering Design Competition

Purpose

The JETS Engineering Design Competition is an opportunity for students to experience simple engineering design. The competitions are designed to encourage group effort but individuals may compete. Engineering design competitions stress creativity and ingenuity as well as an understanding of engineering principles. The students develop a design and build a working model that can be tested in a competitive atmosphere.

These competitions are designed for interesting, stimulating and educational chapter and regional contests. Many of the design problems have been selected from past competitions, some of which have been enhanced by JETS Chapters. Others come from JETS professional resources and other JETS activities.

Within chapters, design groups (three to six students each) may compete. The number of team participants or teams may vary due to the nature of the design problem, the cost and time and manpower available. In regional competitions, the design groups from several areas can compete for championships and see a wide variety of designs for the same project.

General Rules for Design Group Competition

1. Students may participate in the competition as members of one or more design group. It is suggested that the design group be no less than three and no more than six members. All participating groups from a school will comprise a team.
2. Each participating student must be a member of his or her school's JETS chapter.
3. The engineering design problem is one that can be judged on the basis of one or more physical measurements: a distance measurement, weight, time, etc. A test must determine the winning design. Some competitions lend themselves to subjective judgments for creativity, innovative use of materials, documentation, mastery of the problem, etc. These judgments should be made by qualified individuals.
4. The design will use inexpensive materials from local sources that are available to all contestants.
5. The design groups are encouraged to seek an engineering consultant (such as a local practicing engineer) as a team advisor.
6. Students are encouraged to document the design process during development. Documentation (drawings, photograph, written) may be used in some competitions for additional awards.
7. Results of individual competitions and comments regarding the competitions, instructions, materials, etc. should be forwarded to JETS Headquarters for evaluation and review for future competitions.

Specific Rules for Each Design Project

Detailed descriptions of twenty three design problems and variations follow these guidelines. The design projects have been selected with the following purposes or principles in mind:

1. Each design problem is a project that can be completed by the group or individual in one to six weeks.

2. A statement of each design project will include judging criteria.
3. The project should be able to be accomplished by all teams showing reasonable interest.
4. Each design will use one or more engineering principles for solution.
5. The design problems are intended to encourage the groups to do independent study to understand the basic engineering principles.
6. Each design problem provides "hands on" experience in the building of a model to be tested.

Awards

1. It is recommended that an award be given to the 1st and 2nd place design groups that win each design project.
2. A 1st, 2nd and 3rd place trophy may be given to the high school team that earns the most points. 1st place in a design project earns 5 points; 2nd place, 4 points; 3rd place, 3 points; 4th place, 2 points; and 5th place, 1 point.
3. Additional awards may also be presented for creativity, innovative use of materials and/or design, unusual applications of engineering principles, documentation or overall mastery of the problem.

Design Statement

Design and build a toothpick bridge that will support a maximum load.

Design Parameters

The bridge must be no more than 35 cm long and 10 cm high (see Figure 1). Bridge width is unrestricted and lateral stability (resistance to tipping) will be the responsibility of the designer. The top span must have a flat area measuring 5 x 5 cm to be used as a loading platform for testing. The loading block will measure 6 x 6 cm at point of contact with loading platform (see Figure 2).

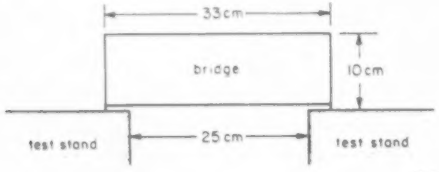


Figure 1

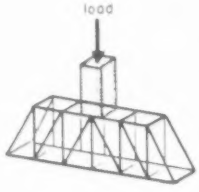


Figure 2

Materials Limitations

Only standard round toothpicks such as Diamond or National Round Toothpicks and Testor's Wood Model or DuPont Duco Cement may be used.

No more than 900 toothpicks may be used. They may be shortened, blunted, bent or spliced. All toothpicks must be visible and any portion of a toothpick used shall be counted as a whole toothpick. Cement may only be applied at joints or splices. Toothpicks of the same direction cannot be bonded together over the length nor can cement be used along the toothpick shaft for added strength.

Testing Conditions

The bridge will be loaded on the center top span (see Figure 2) with standardized weights placed on the 6 x 6-cm loading block. Weights will be added until ultimate failure and the device withstanding the greatest load will be declared the winner. No repairs are allowed during testing.

Variation

TOOTHPICK AND THREAD SUSPENSION BRIDGE - Yuen Yeung Chan, FDR, Brooklyn, NY

A suspension bridge constructed of the above specified toothpicks, polyester/cotton sewing thread and cement, and conforms to similar design and testing conditions can replace the Toothpick Bridge. Revised dimensions are indicated in Figure 3 below. Note that the thread may not be used to bind toothpicks together.

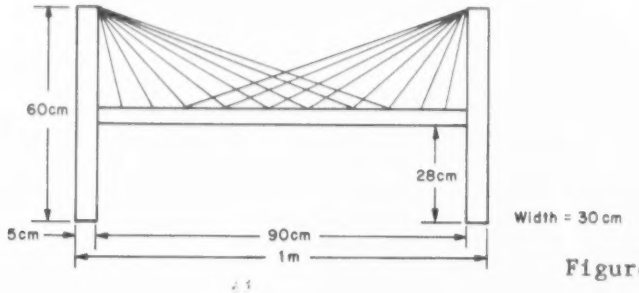


Figure 3

Design Statement

Design and build a bridge with a limited amount of paper and glue to span a space 56 cm wide that will support a maximum load.

Design Parameters

The bridge must span a space 56 cm wide and 80 cm above the floor. The bridge decking must allow passage of a one-kilogram vehicle 12.5 cm wide and 20 cm high. A platform to accommodate the testing weights should be placed in the center of the span.

Materials Limitations

Fifty sheets of 20 lb bond paper, 8-1/2 x 11 inches, and a 36.9 ml (1-1/4 fl. oz.) container of Elmer's White Glue-All are the only construction materials utilized. Lettersize photocopy paper may be substituted, however all contestants **must** use the same type and manufacture of paper. The paper may be cut, folded or rolled.

Testing Conditions

The bridge will be loaded by adding standardized weights to a 12 x 12-cm box placed on the platform in the center of the span. Weight will be added until ultimate and total failure. The bridge withstanding the greatest load will be declared the winner. No repairs are allowed during testing.

Variation

A paper tower constructed of the same materials may also be built. The design parameters specify that the tower should be at least 75 cm high with a minimum of 12 cm diameter at the top and a maximum of 30 cm diameter at the bottom. A platform should be supplied to accommodate the weights in testing. The same testing procedure should be used.

Design Statement

Design and build a toothpick cantilevered arm that will support a maximum load.

Design Parameters

The cantilevered hoist must fit within the box configuration shown in Figure 1. A wooden joist should be placed at a point 29 cm from the left end and 7 cm above the base (indicated by asterisk) for the attachment of a 1/2-inch "s" hook used in testing. Note that the joist may be made from several toothpicks and at this one point, they need not be individually visable.

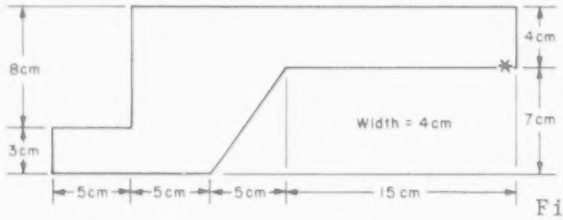


Figure 1

Materials Limitations

Only standard round toothpicks such as Diamond or National Round Toothpicks and Testor's Wood Model or DuPont Duco Cement may be used.

No more than 900 toothpicks may be used. They may be shortened, blunted, bent or spliced. With the exception of the joist, all toothpicks must be visible and any portion of toothpick used will be counted as a whole toothpick. Cement may only be applied at joints or splices. Adjacent toothpicks running in the same direction cannot be cemented together over the entire length for bonded strength, nor can the cement be used along the toothpick shaft for added strength.

Testing Conditions

A loading rig shown in Figure 2 must be built to accommodate the hoists.

The mounting buttress will slide into the loading rig and the load will be applied to the "s" hook using standardized weights in increments. All entries will be loaded to ultimate failure and the device withstanding the greatest load will be declared the winner. No repairs will be allowed during testing.

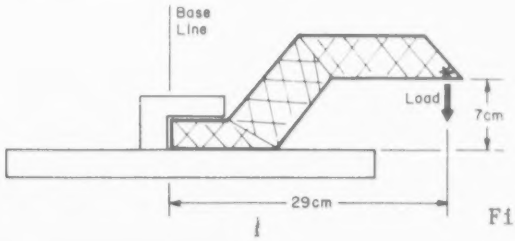


Figure 2

Design Statement

Design and build a tower that will support the largest compressive load and use the least amount of material or the highest strength to weight ratio.

Design Parameters

Overall height will be 38 cm ± 1.25 cm. Tower top must fit inside a 10-cm diameter circle. Tower base must fall outside a 13-cm diameter circle and inside a 26-cm diameter circle.

Materials Limitations

It is suggested that each contestant be supplied with kits containing:

Lattice wood
- 8 pieces 1/4 x 1/2 x 15 in. (38.1 cm)
- 4 pieces 1/4 x 1 x 15 in. (38.1 cm)
- 4 pieces 1/4 x 1 x 8 in. (20.3 cm)
- 4 pieces 1/4 x 1 x 5 in. (12.7 cm)

1 tube Duco cement or equivalent

Testing Conditions

Weigh tower on triple beam balance (grams). Subject tower to vertical compressive force in materials test laboratory Universal Testing Machine. Calculate strength to weight ratio. The highest ratio designates the winner. This represents the best utilization of the materials.

Note As in industry, judicious use of materials is an important factor in the design and construction of buildings. This tower should be constructed to reflect the conservation of our natural resources.

Design Statement

Design and build a model oil derrick from toothpicks that will sustain the greatest load for its mass.

Design Parameters

The model must be at least 35 cm tall and there must be an open space of at least 100 square cm at the base of the model. It must be self-standing and completely open on the inside and at the top and bottom. No internal cross-bracing is allowed. Some portion of every toothpick must be visible from the outside of the model.

Materials Limitations

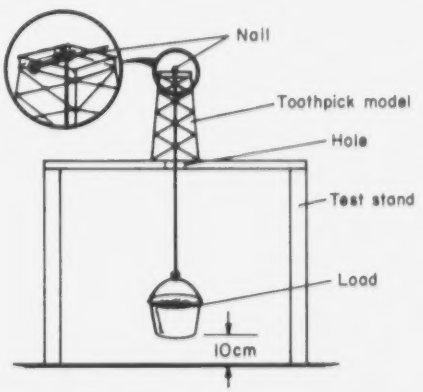
Each derrick is to be constructed from no more than 750 (1 box) flat wooden toothpicks and woodworking glue. A toothpick may be cut, bent or shortened and any portion of a single toothpick counts as an entire toothpick. Glue is to be applied to the toothpicks at the joints and junctions only. There is to be no lamination (spreading glue along the entire length between toothpicks in order to strengthen it).

Testing Conditions

Models will be judged by their strength-to-mass ratios, defined as the critical load (grams) of the model divided by its mass (grams). Prior to testing, the mass of each model will be determined to the nearest gram.

Destructive testing will be performed to determine the critical load. The model will be placed on the test stand shown below. An iron nail or equivalent will be placed across the top of the derrick. The position of the nail may be specified by the builders as long as it is at least 35 cm above the base of the model. A bucket which will contain the load will be attached to the nail using a lightweight chain, or wire that will not stretch, with "s" hooks. The bucket will then be adjusted so that the bottom of the bucket is 10 cm above the floor. The bucket will be loaded with sand until its bottom touches the floor, at which point the model will be considered as having failed. The combined weight of the bucket, load, chain, "s" hooks and nail will be defined as the critical load of the model. This combined weight will be divided by the weight of the mass for the final score.

Note This method of load testing does not necessarily mean the total collapse of the model and may be adapted to other strength and/or stability competitions.



Design Statement

Design and build a balsa wood bridge to meet several criteria: creativity, beauty, neatness, strength and the ability to meet the design parameters.

Design Parameters

The bridge must be a maximum of 40 cm long x 10 cm wide x 22 cm high. It must span a 25-cm "river" with no center supports and have at least 10 cm clearance above the "water" at the center. The design must be freestanding and not fastened to any base. An area of 2.5 x 10 cm must exist at the center of the bridge for the addition of weights to test for strength. It will be judged for beauty, creativity, neatness, strength and meeting these design parameters.

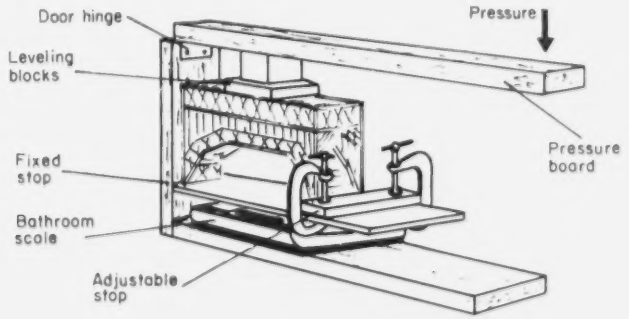
Materials Limitations

Ten 3-foot lengths of 1/4-inch or 3/32-inch square balsa wood--thirty linear feet total and a tube of quick-drying model cement are the only construction materials permitted.

Testing Conditions

The judges will award points for the beauty of the design, creativity or application of engineering principle, following the design parameters, neatness of construction and for each ounce or gram of weight the bridge supports. The first four criteria are subjective judgments with appropriate maximum points established prior to the competition.

The test for strength may be performed in one of two ways. Standardized weights may be added to the area specified in the design parameters until total collapse or ultimate failure of the bridge takes place. The strength-testing device shown below utilizes a digital bathroom scale and may be used in place of the weights. Build the device as suggested in the illustration. For testing, mount the bridge in the fixture and ensure that the pressure board is level by selecting appropriate size blocks to be placed at the specified test area. Set the bathroom scale to zero and apply downward effort to the pressure board until total collapse or ultimate failure takes place. Points for each increment of weight (ounces or grams) will be added to the design and construction scores and the bridge with the most points will be declared the winner.



Design Statement

Design and build a self-contained vehicle using a mouse trap as the only source of energy for one of three competitions: to travel a maximum distance, to stop the closest to a four-meter distance or the fastest over a fixed distance.

Design Parameters

The vehicle wheel and body size are unrestricted, but must have three or more wheels. Any or all parts of the mouse trap may be used in the design, but the mouse trap spring must be permanently attached to the vehicle. The vehicle must be started from a standstill position without the aid of supports or backstop. No push or pull starts are allowed.

Materials Limitations

One McGill Four-Way Mouse Trap (or an equivalent wood and spring mouse trap) will be the only source of energy. The wooden base of the mouse trap and the spring may be mechanically modified, but the spring may not be subjected to any heat treatment process. Wheels and axles may be purchased. There are no other construction materials limitations.

Testing Conditions

The vehicles will be tested on a smooth flat floor (preferably tile or composite material). Each vehicle will be allowed three trial runs with the best performance used as the official test run.

- **Distance Performance Run** - The maximum distance traveled will be measured from the starting line and the vehicle travelling the farthest declared the winner.
- **Start-Stop Run** - The vehicle that stops closest to a line four meters from the starting line will be declared the winner.
- **Time Trial** - Time the vehicle across a fixed distance. The vehicle completing the distance in the shortest time will be declared the winner.

Variations

Record money spent for the development of each vehicle. At testing determine the greatest distance per dollar spent as an additional award.

LE RAT TRAP DRAGSTER

This variation is suggested for senior division JETS members. The rat traps are **dangerous if handled improperly.** The design and materials parameters remain the same except for the substitution of a McGill Four-Way Rat Trap or Victor Rat Trap (or equivalent) as the energy source. The length of the testing area should be extended to approximately 12 meters and vehicle timing should be recorded from the starting line to an appropriate point near the 12-meter line. Exercise **caution** during the development and testing of these vehicles.

Design Statement

Design and build a four-wheeled vehicle to be powered by one or any combination of the following: mouse trap, balloon, rubber band, which can travel ten meters the fastest while carrying a payload of 100 pennies (330 grams).

Design Parameters

Maximum dimensions of the vehicle will be 60 cm high x 30 cm wide x 60 cm long and must contain a holder(s) for two 50-penny bank rolls. The payload should be removable for verification by the judges after testing. The vehicle must be powered **only** by the approved power sources individually or in any combination. The vehicle must stay in contact with the floor at all times and must stay in one piece to be reusuable for several trials.

Materials Limitations

Construction:

paper	wood	lubricant	tin/aluminum cans
tape	string	wire	thread spools
staples	paper clips	coat hangers	aluminum foil
pencils	glue	pins	computer cards
four wheels and axles (commercially bought)			ball point pens
rubber band (not as an additional power source)			

Power Sources:

One 1/4 x 12-inch rubber bands (available at hobby shops)
One wood and spring type mouse trap
One small round balloon (balloons are difficult to specify and organizers may prefer to issue the balloons to ensure similar size and volume)

No other materials may be used. **Definitely** no commercially-purchased gears, bearings, motors or chemical propellents may be used.

Testing Conditions

Construct a track on a smooth floor (preferably tile or composite material) divided into two lanes. Use "2 x 4s" for the center divider and outside guard rails. Each lane will be 60 cm wide by 10 meters long. Two cars will be raced at one time in a double elimination tournament. The payload should be removed after testing for weight verification. All vehicles must remain at the racing site until released by the judges.

Note The organizers may prepare a kit containing the power sources and the wheel and axle system in order to ensure that the essential components are identical for all contestants. Spares may also be included to allow for breakage in the development stages.

Design Statement

Design and build a vehicle that will transport an uncooked chicken egg 7.5 meters in the shortest possible time and stop as close as possible to a solid finish line (a brick wall) without breaking the egg.

Design Parameters

The vehicle must fit inside a 50-cm square box and may be powered by any approved source of energy. Stopping mechanisms may be electrical or mechanical and must work automatically. The vehicle must be started from a standstill position without the aid of supports or a backstop. No push or pull starts are permitted.

The vehicle must have an uncooked chicken egg mounted on the front of the vehicle so that the "pointed" end of the egg is 7 cm in front of the forward wheel edge and 7 cm above the floor. No part of the vehicle may extend beyond the tip of the egg. It must be mounted so that the egg makes first contact with the wall in case of collision. It must have a rigid backstop behind the egg and the egg mount must not be padded. Once the vehicle has been set in motion, it may not be touched until it has come to a complete stop.

Materials Limitations

The power source may be any means: electrical, battery, mouse trap, rubber bands, etc., except no chemical, explosive, radio/computer controlled sources may be used. There are no construction materials limitations. The egg should be an uncooked Grade A Large chicken egg.

Testing Conditions

Designate the testing area by marking on a smooth flat surface the start and finish. The finish line is an existing wall or a solid wall built for the testing and will be located 7.5 meters from the starting line. The vehicle's front wheels will be placed on the starting line and timing will commence when the contestant has set the vehicle into motion. Contestants are allowed two official runs to get the vehicle and egg as close to the finish line as possible in the shortest time. If the egg is broken or cracked on the first run, the vehicle is disqualified from further competition. If the contestant has a good first run, the second run is optional. If the egg is broken or cracked on the second test run, both test runs are disqualified. The vehicle with an unbroken egg and the smallest Performance Value (PV) will be declared the winner. The Performance Value will be calculated as follows:

$$PV = 3T + D$$

where:

T = elapsed time in seconds from start to complete stop
D = distance from egg tip to wall in centimeters

continued

The eggs of all contestants will be broken after the competition to verify compliance with the rules.

Variations

THE ECONOMY RUN

Limit the construction materials and power sources to any of the following and assess each item a dollar value.

Power Source:	
No more than four standard No. 32 rubber bands	$1.00 for four
Construction Materials:	
Tempered particle board, 1/8 in. thick (Masonite)	$0.04 per square inch
Nylon Cord, 1/16 in. diameter	$0.03 per inch
Rod or wire, 12 gage or smaller	$0.03 per inch
Paper, 20 lb bond, 8-1/2 x 11 inch	$0.10 per sheet
No. 32 rubber bands (not used as power source)	$0.10 each
Lubricant	No charge
Glue or model cement	No charge

Note The organizers of the competition may select additional materials and assess a reasonable value to each.

With the exception of the materials limitations, all design and test parameters are the same as the Humpty Dumpty Handicap. The vehicle which achieves the lowest Performance Index will be declared the winner. Calculate the Performance Index by multiplying the Performance Value by the construction cost of the vehicle.

EGGS CAN BE MESSY!

Organizers may want to modify the course by indicating a start and finish line with a race distance of 7.5 meters and the wall placed beyond the finish by one meter. The object is to transfer the egg across the 7.5-meter distance as fast as possible and stop within the one-meter zone without hitting the wall. Timing would be from start to finish without calculating the distance between the stopped vehicle and the wall. Breaking the egg by hitting the wall would be the optimum penalty--disqualification and the vehicle with the shortest time over the distance without breaking the egg will be declared the winner.

Design Statement

Design and build a vehicle that will travel the greatest straight line distance after rolling down a 3.5-meter inclined ramp.

Design Parameters

The vehicle must fit inside a 10.2 x 12.7 x 29.2 cm shoe box and must have a chassis. All parts are to be an integral part of the vehicle (no loose parts). Vehicle weight may not exceed 900 grams.

Materials Limitations

The wheel and axle system may be purchased, although creative use of materials in all phases of construction is encouraged. There is no limitation of construction materials except that clay, lead, steel, or similar material may only be used as ballast. Lubrication may be applied on moving parts and the vehicle may be painted.

Testing Conditions

The inclined test plane will be 3.5 meters long by 15 cm wide and set at a grade of 27% or at a 15-degree angle. A center line will be indicated both on the ramp and the flat surface onto which the vehicle will roll. The vehicle's efficiency is tested by placing the vehicle on a start line marked on the ramp and letting it roll down the ramp without guiding it in any way. Its performance is measured by how far beyond the end of the ramp the vehicle rolls and the distance that the vehicle veers from the center line. The distance that the vehicle veers from center will be deducted from the distance. The best of three runs will determine the winner.

Variation

The size and weight of the vehicle may be varied from very small (less than 15 cm long) to very large (over 40 cm). Size does not alter the basic physical and aerodynamic concepts involved. The ramp size and incline would be adjusted according to the size and weight of the vehicles.

Design Statement

Design and build a boat to be powered by one or any combination of the following: mouse trap, balloon, rubber band, which must carry a payload of twenty (20) pennies a distance of 2.5 meters in the shortest time.

Design Parameters

Maximum dimensions of the boat will be 35 cm high x 25 cm wide x 45 cm long and will carry a payload of twenty pennies--either two sets of ten or one set of twenty. The forward extreme point of the boat must lie above water and the hull must remain in the water at all times. All power must act against water and/or air only. The boat cannot use the sides of the testing trough for propulsion. Sails may be used and a fan set at constant speed will be provided for air current.

Materials Limitations

Construction:

paper	wood	cloth	balsa filler
sealer	string	graphite	thread spools
staples	paper clips	coat hangers	aluminum foil
solder	glue	fiberglas	plastic bags
screws	oil	grease	fishing line
wax	paint	nails	beverage cans
straws	tape	trash bags	computer cards
pens	pencils	saran wrap	straight pins

rubber band (not as an additional power source)

Power Sources:

Two 1/4 x 12-in. rubber bands (available at hobby shops)
One wood and spring type mouse trap
Two small round balloons (Organizer-supplied to ensure equality)
Wind power from constant-speed fan

No other materials may be used. **Definitely** no commercially-purchased gears, hulls, propellers or ball bearings. No electric motors, batteries, chemicals or explosive devices shall be used as propellents.

Testing Conditions

Construct a leak-proof water trough with inner dimensions of 15 cm deep x 30 cm wide x 3.5 meters long for testing. The actual racing distance is 2.5 meters. It is suggested that completed boats be examined by the judges prior to the race. The payload is to be added at the time of the race by the judges. The boat must start from rest and the winner determined by the boat that reaches the finish line in the shortest time. The best of three runs will determine the winner. All boats must remain at the racing site until released by the judges.

Design Statement

Design and build a vehicle or device that will climb a "clock tower" faced with wire screen set at 60 degrees from horizontal in the shortest time.

Design Parameters

The device, at all stages of movement up the screen, must fit within a 30-cm cube. Total weight of the device must not exceed one kilogram. The power source may be either electrical, batteries, balloons, rubber bands, solar, magnetic, chemical or biological (such as a mouse). Any device or mechanism may be used to convert a power source to motive power and/or gripping power. (Even though a biological speciman may be used as a power source, the device to do the gripping and climbing must be mechanical.)

Materials Limitations

There are no construction material limitations, however the total cost of the materials and power source should not exceed $15.00. No rocket engines or explosive chemical propellents will be permitted.

Testing Conditions

The "clock tower" or climbing surface will be an 1/8 x 1/8-inch steel hardware wire screen angled at 60 degrees from the horizontal. The screen will be approximately one meter wide and the timing area will be 4.5 meters long from the start to the finish line. There will be about one meter of additional screen before the start line to allow for the activation of the device and one meter beyond the finish line to halt the device at the completion of the timed run.

Each entry will run by itself on the climbing surface. The climbing time will be the elapsed time between passing the start line and passing the finish line with the front of the vehicle. Time will be measured with two stop watches and an average time computed. Each entry will be allowed two official runs. The best time (or distance if no vehicle reaches the finish line) will be declared the winner.

Note A special prize may be awarded to an entrant whose vehicle is innovative or creative in design.

Design Statement

Design a climbing device that will climb vertically through a 4-inch (inside diameter) plastic drain pipe one meter tall. The device should be designed to travel through the distance in the shortest period of time.

Design Parameters

The device may not be longer than 23 cm. If the device varies in length during operation, the extended length must not exceed the 23 cm. A hand-held loading platform with adjustable wooden supports (Figure 1) or facsimile should be used for the testing procedure.

Materials Limitations

The only power source to be used is a spring mechanism with gears from a Westclox Big Ben or Baby Ben wind-up alarm clock.

There are no construction materials limitations.

Testing Conditions

The one-meter plastic pipe will be placed in a vertical position as shown in Figure 2. A collar with a foam rubber mat will be placed approximately 30 cm below the top of the pipe.

The contestants will load their device on the hand-held loading platform, adjusting the wooden rods to accommodate the device and placed under the pipe. Timing will begin as the device is released from the platform by hand, or by activating a button, lever, clutch, etc. Timing will terminate when the device falls to the collar after emerging from the top of the pipe.

Each entry will be allowed three trials. In case of ties, the average of three trials will be used. The device with the shortest time will be declared the winner.

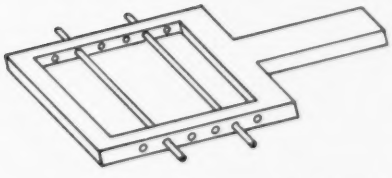


Figure 1

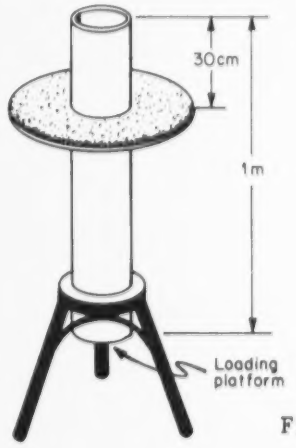


Figure 2

Design Statement

Design and build a rubber band powered device to climb a 15-degree inclined "2 x 4" in the shortest possible time.

Design Parameters

The power source must be rubber bands only and the vehicle can be of any size or design. Slingshooting is not permitted.

Materials Limitations

There are no construction materials limitations.

The rubber bands may be of any size and number.

Testing Conditions

Build a 20-foot ramp of "2 x 4s" at an angle of 15 degrees as shown in the illustrations below. The "2 x 4" will be smooth and straight, but otherwise unfinished.

The device should be placed at a starting line on the ramp so that no part of the device protudes beyond the line. Once the device is set in motion it may not be touched. Each contestant may make three official timed attempts to reach the top of the ramp of which the fastest time will be used. The device that makes it to the top in the shortest time will be declared the winner. If no device reaches the top, the winning device will be the one traveling the furthest. Additional awards may be presented for innovative design or quality of work.

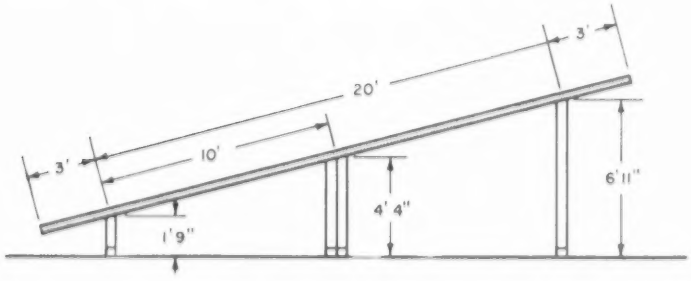


Figure 1

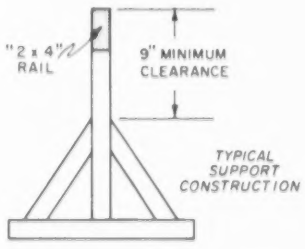


Figure 2

Design Statement

Design and build a wind machine that will carry a weight across a horizontal distance in the shortest possible time.

Design Parameters

The wind machine must fit within a box 24 x 10 x 20 cm high and must use a wooden vertical axle. It must be mounted on a stand so that the axle will be in a position to wind up a cord to which a weight (a silver dollar) has been attached. Possible designs are shown in Figure 1. Collapsible vanes or vanes with moving parts may also be used.

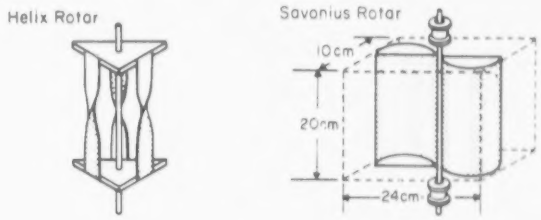


Figure 1

Materials Limitations

There are no construction materials limitations for the wind vanes or collectors. The vertical wooden axle is made of a 3/16-inch dowel no longer than 30 cm. A 4-meter cord will be attached to the axle or take-up spool.

Testing Conditions

Place the wind machine on the floor in front of a fan. Mark out the two-meter timing zone as shown in the illustration below. The contestants may vary the height of the wind machine as desired. The distance from the fan will not vary. Stretch the cord from the machine axle across the timing zone. Tape a silver dollar to the end of the string 1/2 meter from the timing zone. Upon a judge's start signal, the contestant will allow the wind machine to start. The time it takes for the coin to pass across the two-meter timing zone after the initial 1/2-meter "start-up" zone will be recorded. The machine requiring the least travel time through the two-meter zone will be declared the winner.

Note A study of types of windmills: American multiblade, Dutch four-arm, High-speed propeller, Savonius, Flettner, Stuart propeller-type, etc. prior to designing the project model may be advantageous to the students.

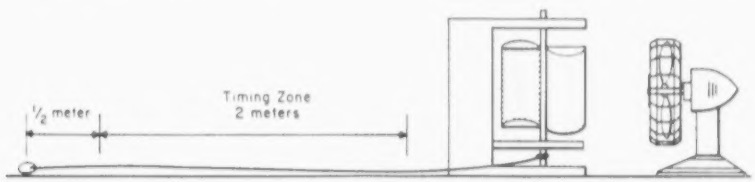


Figure 2

Design Statement

Design and modify two bicycles that will go as slow as possible while maintaining constant forward motion over a-20 meter course.

Design Parameters

Each team must develop and enter two modified bicycles. Each bicycle may have different modifications. The bicycles may be modified in any way so that the modifications do not conflict with any of the following rules:

1. Each bicycle must have only two rubber-tired wheels in ground contact. These will be coplanar with the plane of the bicycle frame when traveling forward.
2. Minimal wheel radius allowed is 15 cm.
3. Tire prints must not exceed a width of 8 cm and a length of 15 cm when the student is on the bicycle.
4. No part of the bicycle except the tires may touch the course.
5. Forward motion shall be provided by the muscles of the rider.
6. No equipment of any sort may be added to the bicycle after it is tire-printed and before the conclusion of the competition.

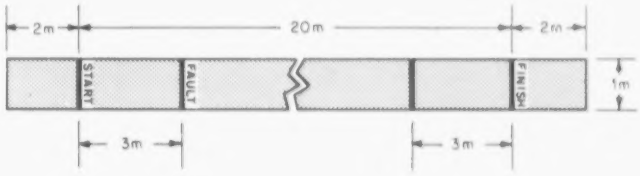
Materials Limitations

There are no materials limitations unless a power device is used for a fly-wheel, and it shall be: a) noninternal combustion, b) nonpolluting, and c) non-oil dripping.

Testing Conditions

The basic course will be 20 meters long and one meter wide. It may be sloped as much as five degrees. If an outside course on asphalt paving is used, it should not be seriously pitted. Shown below is a diagram of the course. The bicycles will begin their motion in the 2-meter starting pit and a fault line will be located 3 meters from the starting line.

Two different students must compete, each piloting a different bicycle. Each competitor must complete one run in each direction and will be permitted one trial run before the official runs begin.



continued

The following rules will apply:

1. No part of the competitor's body may touch the ground outside the starting pit during the run. This will result in disqualification for the half-run.
2. Timing will begin when the axis of rotation of the forward wheel passes the starting line and stop when it passes the finish line.
3. If a bicycle wheel touches the side markers of the track before the fault line is reached, the run is a fault and may be restarted. After the fault line is crossed, touching the width markers of the track results in disqualification of the half-run.
4. One fault is allowed per competitor within the fault box per half-run. A second fault during a half-run will disqualify that half-run.
5. At no time may the bicycle steering wheel point perpendicularly to the width marker lines of the course. This will result in disqualification for the half-run.
6. At all times perceptible forward motion must be maintained. If the motion judge does not detect forward motion, s/he shall begin a count "ONE, TWO, THREE." If perceptible forward motion is not attained by the count of "THREE," the half-run will be disqualified.
7. At no time is backward motion of the vehicle allowed. The motion judge, upon detecting backward motion, however slight, shall declare a disqualification for the half-run except within the fault line, when the run must be restarted.

The event winners will be determined by the sum of the times of the two half-runs. Team scores will be determined by the sum of the times of the two bicycles.

Design Statement

Design and build a power winch that will lift the greatest weight 30 centimeters with the push or pull of a soda straw.

Design Parameters

The winch cannot be larger than 25 cm in any direction (25 x 25 x 25 cm). The loading line must pass through the center of the bottom surface to lift a load vertically (Figure 1). The base of the winch must be 25 x 25 cm for mounting. Any mechanical technique--jacking, gears, friction, etc. may be used to lift the weight. Power will be limited to the push or pull of a soda straw moved through an 8-cm distance maximum on each stroke (Figure 2). The contestant's hand may not hold the straw closer than 8 cm from the point at which it is attached or is in contact with the device. Straws may be attached in any manner but must be exchangeable with new straws issued by the judges at testing. These straws may be adapted to the connection point only. No reinforcement of the straw will be permitted.

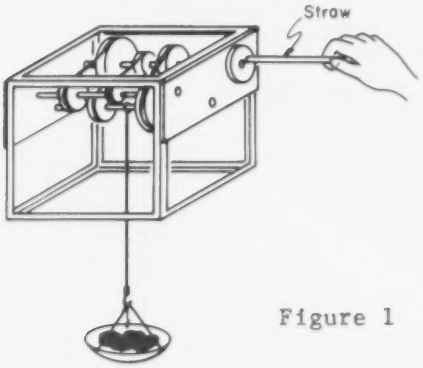


Figure 1

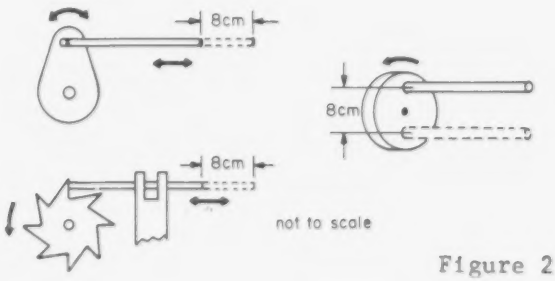


Figure 2

Materials Limitations

Only wood, string, styrofoam, plastic, paper clips (No. 1 or No. 2 size), rubber bands (No. 64 or smaller--1/4 inch wide x 3-1/2 inches long when unstretched), model cement, lubricants, and a 6-mm diameter plastic soda straw (McDonald's, Burger King, etc.) may be used.

Testing Conditions

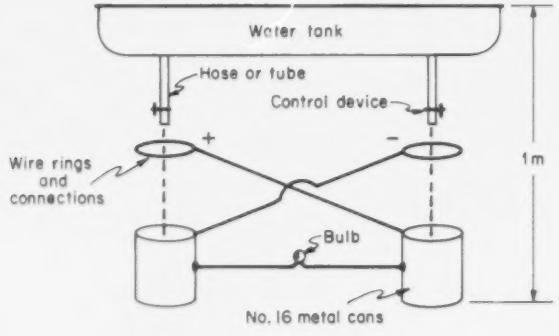
After the winch is placed in the testing stand, the contestant will power the winch by hand with the soda straw for each weight trial. Contestants will be allowed 2 minutes for each lift--one trial for each weight. A contestant may enter at any weight level as the weights are increased. Entry at the first weight level is not required. The weights will be increased until a winner is declared.

Design Statement

Design and build a system that will light a neon bulb the most times in a 60-second period using Lord Kelvin's waterdrop principle.

Design Parameters

The apparatus must be mounted so as to be a one-piece mechanism with a one-meter maximum height as a constraint. The cans may be movable and the rings adjustable. A typical system might appear as the one in the illustration below.



Materials Limitations

A water tank with two outlets to accommodate a hose or tube, control devices or valves for hoses, metal cans and wire. A neon bulb with 25-cm wire leads with metal friction clamps on end may be supplied by the judges or the contestants.

Testing Conditions

The contestants will be allowed adjustments prior to test runs. A two-minute start up period or less will be permitted as a "warm-up". The test run will begin with the contestant saying "Three, two, one, start." The judge will start a 60-second timer and count the number of times the light is illuminated. In case of ties, additional runs may be made.

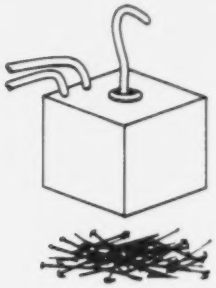
Note Before beginning this project, it is advisable to research Electrostatic principles and specifically, the Kelvin Water Dropper.

Design Statement

Design and build an electromagnet with the greatest magnetic force to pick up the most weight of iron nails.

Design Parameters

The electromagnet should not be larger than 5 x 5 x 5 cm. One surface will have a hook or loop for hanging which may extend beyond the 5-cm height as shown in the illustration below. The opposite surface will be the magnetic pickup. The magnet will be powered from a 12-v dc source and two electrical leads may be attached anywhere on the magnet.



Materials Limitations

The two electrical leads should be at least 20 cm long with appropriate connectors to the power source. There are no other construction materials limitations.

Testing Conditions

The magnet will be connected to the 12-v dc source and judged on the basis of the weight of iron nails (or other magnetic material) that can be lifted.

Design Statement

Design and build a vehicle that will travel a distance and while moving automatically launch a pencil missile at a target.

Design Parameters

The vehicle must fit inside a rectangular box 30 cm wide x 60 cm long and 60 cm high and may be powered by any means. The vehicle must start from a standstill without the aid of supports or backstop. No push or pull starts are allowed.

The missile must be constructed from a pencil and mounted on the vehicle at a 45-degree or greater angle to the floor and fired automatically. Additional power source may be used in the missile launch design.

Materials Limitations

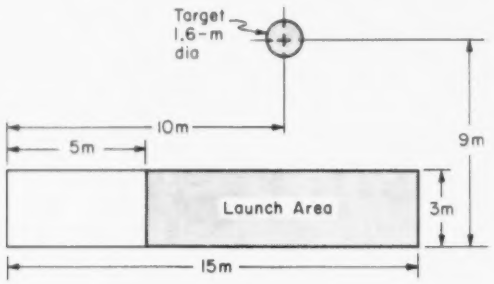
There are no construction materials limitations for the launch vehicle.

The power source may be any means: electrical, batteries, clock spring, rubber band, etc. No chemical or explosive devices may be used.

The missile must be constructed from a standard yellow wooden pencil which may not be shortened to less than 15 cm. Fins may be added but the eraser must not be modified. Grease will be applied to the eraser to mark the impact point.

Testing Conditions

The vehicle will be tested on a smooth floor on which the boundaries shown in the illustration below have been marked. The vehicle must start from a standstill, proceed to the launch area and automatically fire the missile at the target while moving. The vehicle must remain in bounds at all times until after the launch. Each contestant will have two official runs. The missile whose impact point is closest to target will be declared the winner.



Variation

SPRING PONG LAUNCH

Design and build a device that will carry and launch a ping pong ball. The vehicle will be propelled and the ball launched by two standard alarm clock springs or two mouse trap springs or one of each in any combination. There are no other materials limitations. The device is to be set in motion on a starting line and carry the ping pong ball two meters before launching the ball towards a target. The ball landing closest to the target will be declared the winner.

Design Statement

Design and build a shipping container that will prevent an uncoooked egg from breaking when dropped from a ten-meter height.

Design Parameters

The container must be less than 400 cm^3 in volume with no dimension longer than 25 cm. Maximum weight including the egg cannot exceed 1 kilogram. Contestants must be able to remove the egg without damage. A maximum of 30 seconds will be allowed to place the egg in the container and remove it.

Materials Limitations

There are no construction materials limitations. The egg should be a Grade A Large chicken egg.

Testing Conditions

Each model will be measured, weighed and drop tested from a ten-meter height. The value for each model will be evaluated as follows:

$$V = \frac{75S}{(W + L^2 + X)}$$

Where:

V = Value

W = Weight (grams)

L = Longest dimension (cm)

X = Volume (cm^3)

S = Success factor (100 if egg does not break)
(0 if egg breaks)

Variation

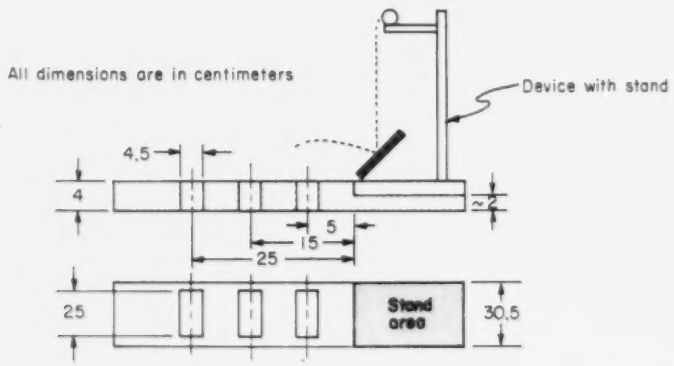
Design a package to keep three uncooked eggs from breaking when dropped from a height of 2.5 meters. The volume of the package cannot exceed 1600 cubic cm.

Design Statement

Design and build a mechanism to drop a ping-pong ball from a height selected by the contestant onto an adjustable angled surface so that with one bounce, the ball will enter openings in a scoring board.

Design Parameters

A stand, loading platform and angled surface should be designed so that it may be C-clamped to a test fixture (scoring board). Ping pong balls will be dropped from the adjustable platform to the adjustable angled surface and bounced into three openings (or slots) of 4.5 cm x 25 cm at 5, 15, and 25 cm from the stand. The height and the angle of the surface may be selected at the time of testing for each distance of the openings, however the stand must remain fixed. The position of the device and the dimensions of the scoring board are shown in the illustration below.



Materials Limitations

There are no construction materials limitations. The ping pong ball will be of official size and weight without modifications.

Testing Conditions

Once the device in clamped into position on the scoring board contestants will have five minutes to complete their test run. Each entrant may "shoot" two trial shots before three official shots at each distance. A "hit" is defined as a shot that clearly enters the target slot from the angled surface in one bounce. Shots that enter the target slot as the result of successive bounce(s) or roll will be declared a "miss". The following scoring shall be used to determine a winner:

At 5 cm: Number of hits x 4
At 15 cm: Number of hits x 7
At 25 cm: Number of hits x 9

The contestant with the most points will be declared the winner.

Design Statement

Design and build a device that will propel or move eleven tennis balls into a target bucket approximately three meters away for under $5.00. This is a team activity with five contestants per team. One device for the team or individual devices for team members are acceptable.

Design Parameters

The device should propel eleven tennis balls, individually or simultaneously approximately three meters to a target bucket and must travel a minimum of the last 1.5 meters freely in the air or bouncing into the scoring bucket. Refer to Figure 1 for "court" dimensions and "playing" zones. The device shall be of any size and design and must cost under $5.00 to develop and build. It may be hand-held or floor-supported. Each player will have two minutes to complete a trial.

Materials Limitations

There are no construction materials limitations. Tennis balls shall be regulation tennis balls and cannot be altered by any means. Eleven balls will be marked with the team/school name only and one of the balls will be colored red to be used as a bonus ball. The balls will be placed in a team bucket approximately 25 cm in diameter by 23 cm tall and appropriately marked with team/school name.

Testing Conditions

Figure 1 shows the "court" dimensions and "playing zones". The court consists of the scoring bucket which is placed in the center of a 3-meter radius circle with up to seven equispaced 60 x 60-cm squares 60 cm from the circumference. The 3-meter radius is divided into two zones of 1.5 meters. The outer 1.5-meter area is designated the "Foul Zone", the inner 1.5-meter area is the "Dead Zone" and the dividing line called the "Dead Line".

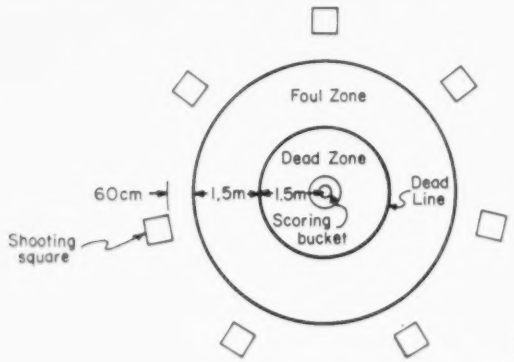


Figure 1

continued

The scoring bucket (Figure 2) may be a galvanized or plastic bucket no larger than 25 cm in diameter from which the bottom is to be removed. The bucket is placed into a cardboard, plywood or plastic top which covers a 20-gallon trash can. This will prevent the balls from bouncing out.

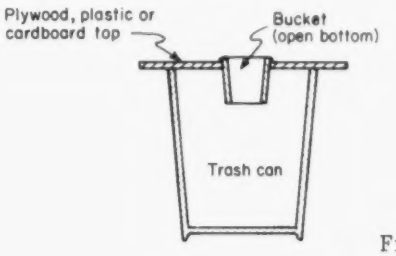


Figure 2

One player from each team will take his/her place on the 60-cm square maintaining one foot on the square at all times during the trial. The team ball bucket is placed next to the square. The contestant may not step or reach into the foul zone nor may the device touch the foul zone floor. The device may extend into the foul zone but not extend beyond the dead line. Once a ball has been "shot", it cannot be retrieved, nor can the play of an opponent be interfered with.

At the judge's signal, the players will commence using their device to propel or move their balls toward the scoring bucket until either all the balls in the team bucket are expended or the judge signals the two-minute period is complete. The judge will then count and record the balls in the scoring bucket and return all the "shot" balls to the team bucket. This procedure will be repeated for each team member.

Team scoring will be as follows:

	Team Score
Two points for each plain ball in scoring bucket	100 max
Ten points for each red bonus ball in scoring bucket	50 max
Subjective judgment of device design - five points each	25 max
Subjective judgment of creative solution - five points each	25 max
Total	200 max

Individual penalties will be as follows and deducted from the team score:

Reaching or stepping into the foul zone	-3
Deliberately interfering with opponents play	-5
Crossing dead line with device	-5
Exceeding $5.00 construction limit	-10

There is no penalty for one player's ball accidentally hitting an opponent's ball. If an opponent deliberately interferes with a player's ball, that ball is not to be replayed, but the player is awarded 5 points for that ball.

The team that has accumulated the most points will be declared the winner.

Meeting Miniprojects

The Miniprojects are designed for chapter meetings and other JETS activities. The following pages contain projects and activities that can be completed within two hours. Some of the activities require model building, while others require pre meeting research. Some are games, some are competitions. Many of the activities are designed to stretch the imagination, tap the creative resources, stimulate problem solving abilities and promote technological literacy.

A number of the activities are suitable for teams, otherwise individual participation is encouraged. The miniprojects do not contain many imposed limits or rules. They were designed with the idea that individual chapters may adapt the activities to their needs. The membership and the advisor may set additional guidelines or determine the finite limits or rules to a project.

Miniprojects may also be the basis of interchapter competitions. Members can develop the guidelines and parameters for these competitions as an activity within itself.

Comments or critiques of these activities should be forwarded to JETS Headquarters for evaluation and review to aid future JETS activities.

Design Statement

Design and construct a paper airplane that may compete in any or all of the following competition categories:

- Height of Flight
- Length of Flight
- Duration of Flight
- Acrobatics

Design Parameters

The weight of the airplane should not exceed 25 grams. Thirty minutes will be allowed to design and construct an airplane from the cutting and folding of one sheet of paper. Paper clips, tape or glue may be used to hold the airplane together, but the use of additional cardboard, wood or any other material is not permitted. The airplane must be launched by hand and no mechanical or electrical launching devices may be used.

Materials Limitations

Each entry must be constructed from a single sheet of 8-1/2 x 11-inch 20 lb bond paper. Four paper clips, masking or transparent tape and quick-drying model cement may be used to adhere the parts and folds of the entry.

Testing Conditions

Each entrant will have three chances to demonstrate the performance of the entry in any or all of the competition categories. Subjective judging will determine the winner in each category.

Variations

VARIATION 1 - This competition may be expanded to an Engineering Design Competition. Paper airplanes are to be developed individually or as a team using the same design parameters, materials limitations and testing conditions. Once the airplane is developed, an exact layout of the airplane with fold and cut lines clearly indicated should be transfered to another sheet of paper. This exact layout should be submitted to the judges prior to the competition. Photocopies of the airplane layout will be given to the entrants on the day of the competition. Thirty minutes will be allowed for the entrants to assemble their entry.

VARIATION 2 - Follow the instructions for Variation 1 except on the day of the competition the photocopies are handed out randomly. The entrant will now have to construct an airplane from another's plan. Scoring is based on two criteria: How well a plane performs when built by another and how well an entrant builds another's plane. This puts emphasis on the ability to communicate: how well one can draw a plan and how well one can read a plan.

Design Statement

Given an equal amount of material and time, each participant is to make a link of a chain. The links will then be attached and a tug of war will take place. As an individual's link is broken, he/she is eliminated from the contest.

Design Parameters

A link will be constructed from the materials issued by the competition organizer. Each link will have an opening which two 12-inch pieces of clothesline will pass through. The clothesline will be tied to the clothesline of another's link. The clothesline may not be used to strengthen a link.

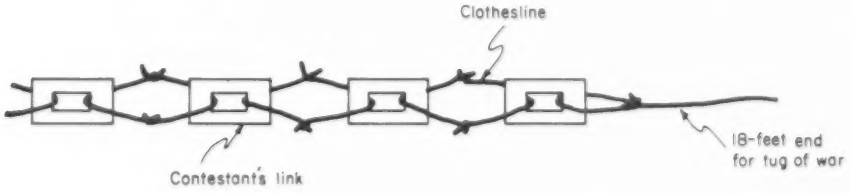
Participants will have 20 minutes to design and construct their links.

Materials Limitations

Each participant will be given one 8-1/2 x 11-inch piece of 20 lb bond paper, one 1 x 2-inch pressure sensitive label or a 1 x 2-inch strip of masking tape, a 6-inch piece of string and a rubberband from which a link is to be constructed.

Testing Conditions

Attach the links with the pieces of clothesline with a square knot as shown in the illustration below. Attach a long rope to each of the end links. (If there are more than ten participants, it is suggested that two chains be formed and ten or less finalists be determined.) Complete a tug of war with the elimination of each participant whose link has failed. The remaining link will be declared the winner.



Design Statement

Design and build a device using a mousetrap which will put out the flame of a typical birthday candle.

Design Parameters

The only source of energy is a mousetrap and a limit of $2.00 in materials. The mousetrap device may not be placed within one meter of the candle, but can be 15 cm above or below the base of the candle.

Materials Limitations

The power source shall be the standard wood and spring mousetrap. There are no construction materials limitations, however a maximum of $2.00 can be spent on all the materials including the mousetrap.

Testing Conditions

The device has to put out the flame within the candle's normal life. If the flame goes out of its own accord, the design problem has not been met and no points are awarded. The participant gets one chance to put the candle out without penalty. Then each attempt is penalized 1 point. If the flame is extinguished on the first try, 25 points are awarded. Team scores may be added together.

Design Statement

Design and build a structure to support a moderately-sized paperback book at least 15 cm off the ground using cost of materials as a major design consideration.

Design Parameters

Allow 15 minutes to draw a plan for your structure. Each allowable construction material has been assessed a dollar value which should be taken into consideration while designing the structure. Allow 15 minutes for the construction of the structure.

Materials Limitations

Rubber bands	$10 each
Paper clips	$25 each
Plastic soda straws	$75 each
Paper, 8-1/2 x 11-in. bond	$200 per sheet
String	$50 per foot

The paper may be bent or rolled and the straws may be bent or stacked. The rubber bands, paper clips or string may be used to secure the other materials. The paper clips may be used as weights.

Testing Conditions

Test the structure by placing the book on or in the support designed to hold the book. Discuss each design and what might be changed to enhance the design. Total the money spent on the materials. Discuss the cost benefit of the structure.

Design Statement

A team of two will design and build clay boats that will withstand the most amount of added weights before sinking.

Design Parameters

The team will have fifteen minutes to construct two clay boats. There are no restrictions for the boat size, weight or design, however no devices (rolling pins, etc.) may be used to shape or form the boats. Weights will be added until the boat sinks.

Materials Limitations

Two 125-gram packages of Plasticine or non-water soluable modeling clay are the only construction materials used. Team members may pool their clay. A soda straw, weights and a large container of water are necessary for the testing procedure.

Testing Conditions

Float one of the boats in the container of water. One member of the team will add uniform weights one at a time until the boat sinks, while the second team member keeps the boat from touching the sides of the container with the soda straw. As the boat becomes sinkable, the judge will request that a second or more elapse between the weight additions. The test will be repeated for the second boat. The winner will be based upon the mass of the weight added before the boat sinks. The weights will be dried and weighed after each trial. The team score will be determined by the sum of the added mass for the two entries, with the highest being declared the winner. A tie will be broken by giving the teams 110 grams of clay to construct one boat. Repeat the testing procedure.

Competition Statement

Two or more teams will have the opportunity to display their knowledge of mathematics and the sciences which are basic to engineering in a question and answer competition.

Competition Parameters

Two or more teams of four or five members will answer questions presented by the moderator. The time period for each question is five minutes.

Questions are prepared in advance, usually by math and science instructors of the school. Each question and answer is typed on a 3 x 5 index card and sealed in an envelope. The questions are chosen randomly by the moderator and presented to each team alternately. A question is presented to an individual team member in rotation. It is the responsibility of that team member to answer the question within three minutes or the team within five minutes. A correct answer by the first individual results in five points for the team. If that individual cannot answer the question, he/she may seek the advice of one team member and a correct answer within four minutes results in three points. If the pair cannot answer the question, another team member may be consulted. A correct answer within five minutes results in one point for the team. Failure to answer the question correctly results in no score. That question is discarded and a new question selected for the opposing team.

A panel of judges or the moderator, drawn from the school faculty or a JETS advisor, will evaluate a questionable answer for accuracy. The team with the highest score at the end of a predetermined number of questions or a time period will be declared the winner.

Interchapter Competition

Engineering Down may be expanded to an interchapter competition with each chapter fielding a single team. It is possible for more than two teams to compete. Questions and answers would be prepared by the faculty of the schools represented in the same manner as the intrachapter competition. It is recommended that three or four judges be available for an interchapter competition.

This competition could be an annual event for which a traveling trophy would be awarded to the winning team for display in their school.

Sample Questions

1. What is the difference between the least common factor of 60 and 72 and the greatest common factor of 60 and 72?

continued

2. Four angles of a pentagon have measures of 100°, 107°, 110° and 118°. What is the measure in degrees of the fifth angle of the pentagon?

3. What value of n makes the sentence n/9 = 5/7 true?

4. What is the total surface area in cm of a cube whose edge measures 9 cm?

5. A ladder 26 feet long is placed against a building so that its foot is 10 feet from the base of the building. What is the height in feet that the ladder reaches up the side of the building?

6. The measure of one angle of an isosceles triangle is 72 . What is the measure in degrees of either of the other two congruent angles?

7. What is the probability that the first two cards drawn at random from a standard deck of playing cards will be kings?

8. Which temperature scale has the largest size division?

9. Explain how an ablative heat shield on the nose cone of a rocket dissipates heat?

10. Perform the following binary number arithmetic: 1101 - 110 + 101001, and convert the answer to a decimal number?

11. What are three of the most important general properties possessed by matter of all kinds?

12. Define what is meant by the density of a substance?

13. State Boyle's Law.

14. State Newton's Laws of Motion.

15. What is meant by Conservation of Mechanical Energy?

16. What is the Brownian motion, and what does it show about the structure of matter?

17. What is meant by the absolute (or Kelvin) scale of temperature?

18. Distinguish between longitudinal and transverse waves.

19. State the Law of Reflection of light.

20. Name the regions of electromagnetic waves that are shorter and longer than visible light.

21. State Ohm's Law.

22. Distinguish between mesons and baryons.

Note Math questions are from MATHCOUNTS 1984-85 Competition and reproduced with the permission of the National Council of Teachers of Mathematics.

Group effort is a very common approach to problem solving. In industry groups of engineers and scientists will often meet in order to suggest possible solutions or alternatives to design problems and perhaps begin the solution process. These sessions are called "brainstorming" sessions. JETS members can also "brainstorm". Below are ideas for discussion as well as an outline of the engineering design method which can be used as a model for discussions. (An expanded version of the design method can be found on page 46 in Engineering Problem Solving Competitions.) Participants are encouraged to research the topic and develop ideas and alternatives before the "brainstorming" session is to take place.

The Engineering Design Method

1. Define the problem.

2. Assess the need and priorities.

3. Determine the scope and limitations and clarify restrictions.

4. Choose a theory or model by selecting the physical laws and engineering arts that would apply.

5. Generate alternatives.

6. Gather required information and complete a description of the elements of the proposed designs.

7. Evaluate the alternatives.

8. Refine the design of the best alternative.

9. Assess the side effects, consequences and cost/benefit.

This outline is suggested as a format in approaching engineering discussion ideas as well as design and problem solving activities.

Example:

Start a discussion about the redesign of public buildings to make them accessible to the physically handicapped. The law requires that all public buildings being planned or remodeled comply with special standards. The standards require wider doors that a wheelchair can fit through. Ramps should be built near stairs. Alterations to help blind and hearing-impaired people identify room numbers and other locations would be made.

In actual practice, very little has been done to comply with the regulations. Monies allocated for these projects do not go very far. Can engineers tackle this problem in other ways? Are there other technological solutions that might be considered?

Engineers may see the problem in different ways. Instead of retrofitting buildings or widening doors, could not a wheelchair be designed that could

"climb" stairs and be thin enough to fit through existing doors? Can a standardized audio/tactile "map" be developed to coordinate maneuverability and locations? This is just a small sample of possible solutions to this problem. The next step is to research the available information and evaluate the alternatives.

Encourage discussion of all facets of engineering design--the problems, solutions, alternatives, and the social and economic ramifications of the design.

Discussion Ideas

SOLID WASTE - Solid waste disposal is rapidly becoming one of the major environmental problems of this decade. Land-fill sites are closing, enviroments are being polluted. As an engineer, what alternatives can be developed to alleviate this situation?

AUTOMOBILE SAFETY - The design of an automobile often contributes to the cause of an accident. As an engineer, how can these design flaws be corrected and still have an automobile that is attractive to the consumer?

MYOELECTRIC PROSTHESES - The electrical activity within an amputee°s remaining muscle is used to control the movement of a prostheses. As an engineer, how can more versatility of movement be achieved?

SPACE HEATING - In many parts of the United States about 50 percent of domestic energy use is for space heating. One of the major causes of heat loss is through doors and windows. As an engineer, can the design and materials of doors and windows be improved to reduce heat loss?

FIBEROPTICS - The use of fiberoptics is increasing daily. Not only is it used to transmit light for medical exploration, but it is replacing copper wire for communications. As an engineer, are there other applications for fiberoptics?

FIRE SAFETY - Structure fires remain one of the most important national problems. What role can the engineer play in the science of fire prevention and firefighting? In particular, discuss materials, fire detection or firefighting equipment.

COMMUNITY PROBLEM - Within the community there may be several technological problems. The solutions to many of these problems--pollution, water shortage, urban blight, transportation congestion, energy generation, etc. are dependent on the devices, designs, systems and expertise of engineers. Isolate one problem and discuss alternative solutions.

There are an unlimited number of technological or engineering topics for discussion. Topics can be very broad or, in certain areas, it may be advisable to focus on one aspect of a topic. Following are additional topics which may be developed:

Artificial Heart	Computer-aided Design	Auto Safety Restraints
Robotics	Synthetic Fuels	Building Materials
Bio Materials	Hybrid Vehicles	Noise Pollution
Acid Rain	Aids for the Blind	Energy Use

Brainteasers consist of exercises designed to "stretch the imagination" and stimulate creative problem solving. A statement is given for which a number of answers are evoked from participants. There are no "right" or "wrong" answers. Any answer no matter how "crazy" it may sound is a correct answer, however the answer should be relevant to the problem. Simply write down responses to the statements given below with as many answers as possible. The responses may be scored as indicated in the scoring section.

Example

Q: Six or more ways to make a reflecting surface

A: 1. Use tinfoil 2. Get a kit from Edmund Scientific Company 3. Polish it 4. Pour liquid in a dish 5. Use fine grit, finish with jeweler's rouge 6. Deposit silver, aluminum, copper, etc. on surface 7. Blow a soap bubble 8. Rub with soft cloth 9. Hand a plain piece of paper to Midas 10. Apply nail varnish 11. Take a surface and teach it to think 12. Electrodeposition of metal, then rub down 13. Stop disturbing the water 14. Put glass on it

Questions

1. Six or more ways to produce electricity
2. Seven or more reasons for not having computers
3. Six or more ways to move a vehicle without an engine
4. Nine or more uses of dust
5. Eight or more problems that had to be overcome to fly to the moon
6. Seven or more ways to carry ten wooden hangers
7. Six or more ways to light a pipe
8. Seven or more ways to prevent a candle from burning down
9. Eight or more new uses for cellophane tape
10. Seven or more things you would have to change about your body to become a bird
11. Eight or more non-writing uses for a pencil
12. Seven or more novel uses of crushed ice
13. Six or more ways to avoid spilling coffee while driving

14. Six or more uses of the jet stream

15. Eight or more reasons for not exploring Mars

Scoring

1. For each answer up to the number requested, one point

2. For every answer over the number requested and under 25, two points

3. For answers 26-30, three points

4. For answers 31-50, four points

* Mental Jogging, Reid J. Daitzman, Richard Marek Publishers, New York, NY, 1980

365 Games to Enjoy, to Stimulate the Imagination, to Increase Ability to Solve Problems and Puzzles

Questions and example are from Mental Jogging and used with permission of the author and publisher.

Omni magazine held a competition asking for speculations, suggestions for novel experiments, unusual applications of technology, machines that should be built, etc. This idea came from a book The Scientist Speculates in which the author, I. J. Good, calls **partly baked ideas (pbis).**

JETS members will have the opportunity to tap their creative resources and stretch their imaginations in a scientific venue. There is no end to imaginative solutions to scientific problems, designs for systems or machines to accomplish heretofor impossible tasks, or the original application of an existing technology to a new problem, etc. Members can participate in this activity in one of two ways: a group discussion format or a competition. In either case, the member will be encouraged to choose a topic (a pbi) and think it out carefully. The idea should be original, creative, imaginative, resourceful, but should not be too esoteric or impractical.

Group Discussion

Each participant will be asked to present one or more pbis to the rest of the group. Participants are encouraged to discuss the pbi, question the validity, contribute to the idea or design, suggest alternatives, etc.

Pbi Competition

Each participant will be asked to prepare and present one or more pbis to a panel of judges. It should be in written form with appropriate illustrations or other presentations to clearly state the idea. Each idea should be limited to 300 words and four illustrations. Judging should be for originality, creativity, scientific validity, workability, mastery of the problem and presentation.

Sample Pbis

An auto design for deaf people; clock radios with two volumes: one to sleep with and another to wake with; cordless computer components; tapping unused energy sources--rain, auto exhausts, etc.; perpetual motion machines; a biomedical device to control hypertension; a biomedical device to alert an individual to the presence of a high pollen count or allergens; alternative uses or disposal of solid wastes; a better mouse trap.

Competition Statement

Each participant is to collect technological artifacts that are not easily identifiable and bring them to the competition site. The object of the competition is to challenge the technical IQ of participants in identifying the items.

Competition Parameters

Participants are encouraged to locate technological artifacts such as old automobile parts, electronic components, motor or engine parts, drafting equipment, tools, hydraulic components, etc. These items are often found in closets, attics, basements, garages and storerooms of members homes. The JETS industrial sponsors, your school and repair shops in your community may also be a source for old or out-dated technological items.

Each item is to be introduced to the participants and they are to answer as many of the following questions about that item as possible:

1. What is the item?
2. How old is it?
3. What is its function?
4. What principles are employed?
5. Has it been replaced?
6. If so, by what?

Additional questions may be established for a particular item as necessary. A discussion of each item should follow the question period.

Points may be assigned for each question with the participant who answered the most questions accurately and accrued the greatest number of points will be declared the winner.

Engineering Problem Solving Competition

The Engineering Problem Solving Competitions are competitions designed to emphasize the pen and paper approach to the mathematical, technical, economic and social aspects of engineering problems. Also included is a competition designed to display the expertise of JETS members in programming for the microcomputer.

The **Technical Papers Competition** stresses the importance of library investigation and research, the interpretation of data, objective decision-making and the demonstration of communication skills, both written and oral.

This activity is suitable for individual participation in either an intrachapter or interchapter competition. Included are competition guidelines, rules, evaluation form and suggested topics. Note that the guidelines and rules were written with an individual in mind, however this does not preclude a group or team effort in preparing technical papers.

The type of topics which this activity encourages is in response to contemporary technical innovations or problems, mathematical design or modeling, analysis of an engineering problem, or the history of the development of an engineering concept. The demonstration of creativity, originality and knowledge of the subject is promoted.

The **Problem Solving Competition** deals with specific engineering problems and economic considerations. These problems are formulated by a practicing engineer and are designed to familiarize participants with the type of work performed in industry.

The problem will have two or more alternate solutions which the participant must research and develop in order to make a judgment as to the best possible solution. The solution will be presented in both a written and oral form, and will be evaluated by a panel of judges.

It is a team project encouraging the sharing of responsibilities and communication. The Problem Solving Competition is suitable for both an intrachapter and interchapter competitions. Included are guidelines, rules suggested problems and a sample question and solution.

Preceding these competitions is an outline of considerations helpful to effective problem solving--The Engineering Design Method. This is included as an aid to assist JETS members in developing solutions, ideas and technological assessments.

The **Computer Problem Solving Competition** utilizes programming skills for the microcomputer to solve problems. Teams will compete to solve specific problems withing a certain time period. Two divisions: junior and senior, will permit the demonstration of programming expertise in either an intrachapter or interchapter competition. This competition stresses team work and good BASIC programming skills. Included are the competition format, judging and scoring criteria and sample problems.

This outline of considerations is the basis for engineering problem solving. They are considerations that engineers often apply in industrial applications to design problems.

1. Determining Need

The ultimate concern of engineering is for utility and for fulfilling the needs of humanity.

- Why do the work?
- Who has determined that need exists and by what criteria?
- Are needs purely physical or economic or is there a social dimension?

2. Defining the Problem

State in the most general terms possible what is to be accomplished.

- Does your statement set a clear objective?
- Are any potential solutions ruled out by an excessively specific or restrictive statement?

3. Determining Scope and Limits

Clarify restrictions and the realm of allowable solutions.

- What bounds are established by time, costs, space, safety, production capabilities and processes, aesthetics, energy costs, ecology, or need to recycle?
- Are boundary conditions independent and absolute or can there be trade-offs and modifications?
- What limits are imposed by standards or codes?

4. Choosing Theory or Model

Select physical laws and engineering arts that relate to the design concept.

- Does adequate knowledge exist to quantitatively relate environmental influences and system behavior?
- Which parameters that define the problem will be selected for consideration?
- What is the degree of reliability or limit of application of the theory?

5. Generating Alternatives

Think of as many solutions as possible.

- What use can be made of principles from nonengineering fields?

6. Gathering Required Information

Complete a description of the elements in each of the proposed designs.

- If it is known, where do we find it?
- If it is unknown, what research do we perform?
- What guesses or estimates do we have to make?
- What is the validity of the information used?

7. Evaluating Alternatives

Select the best solution?

- What criteria shall be used?
- If physical tests are required, which do we select to simulate possible service conditions?

8. **Optimization**
   Refine the design of the best alternative.

9. **Implementation**
   Produce your design.
   - To what extent is the final real object, process or system different from the concept?
   - What are the "errors of translation"?
   - What is the effect of every "part" on the "whole"?

10. **Evaluating Performance**
    Test design when subjected to the environment of actual service.
    - To what degree does the product of the design satisfy the original design requirements?
    - Can the product be improved?
    - Did the design process anticipate the nature or effect of elements of the service environments?

This Engineering Design Method was adapted from Engineering Education, January 1976.

Engineering Problem Solving Competition

The purpose of the Technical Papers Competition is to familiarize JETS members with the written form of problem solving and to stress the importance of research, interpretation of data, objective decision-making and the succinct communication of ideas. Engineers working in industry frequently must present their ideas in a written report. Proposals for funding or contracts, reports to management or customers, technical papers for publication in a professional journal, are only a few applications of the technical paper. In addition, participants will be asked to present their papers orally to the judges at the final competition

JETS members will have the opportunity to demonstrate their technical expertise in the written form in this competition. This activity can be an intrachapter or an interchapter competition. The same rules are applicable for both types of competitions.

The topics may be drawn from many sources. In general, topics may be:

- in response to a contemporary technical problem demonstrating engineering and mathematical design and/or modeling
- an analysis of a problem involving a basic principle of engineering or science
- innovative applications of a scientific or engineering concept
- the history of the development of an engineering concept or model

Suggestions for individual topics can be found on page 51.

The papers should be innovative and creative and must display evidence of library investigation and research, exhibit a knowledge of primary and secondary source materials and demonstrate knowledge of the subject. The Engineering Design Method on page 46 of this section will be particularly helpful in organizing and developing ideas.

The oral presentation of these papers will take place at a predetermined time and place and in the presence of the judges. The judges will not only evaluate the written paper, but will have the opportunity to question the participants regarding their paper. The oral presentation will be included in the overall evaluation of the paper.

The technical papers will be judged on the following basis:

1. Creativity of approach
2. Originality
3. Knowledge of the subject
4. Interpretation of the data
5. Organization
6. Presentation

The judges will be chosen for their ability to give an impartial opinion on a broad area of topics, as well as the technical expertise to effectively evaluate engineering concepts and the written and oral presentation. Prior to the competition, a briefing session will be held for the judges. The competition organizers should outline the goals and methods of evaluating these papers. A sample evaluation form is found on page 50.

Engineering Problem Solving Competition

Topic: The paper may be written on any subject concerning engineering or applied science. It is recommended that the writer not be too broad or vague in the choice of a topic. Consult the guidelines and the list of suggested topics for clarification of a preferable topic.

Length: The paper must be 2,000 words or less in length.

Written Presentation: The paper must be typewritten or word processed, double spaced and in good form. The paper should contain the following divisions in the order listed below. Each division except the frontis matter should be clearly identified as major headings in the paper.

FRONTIS MATTER:
1. Letter of transmittal
2. Title page
3. Abstract
4. Table of Contents

I. INTRODUCTION
II. BODY OF REPORT
III. CONCLUSIONS
IV. BIBLIOGRAPHY

Oral Presentation: The paper will be read in the presence of the judges. Tables, graphs or illustrations should be presented independently as photocopies, slides or overhead projections. The judges will question the writer after the presentation.

Authorship: The paper must have only one author. The author must be a current JETS member. No professional assistance will be permitted and the paper must be the original work of the author.

Deadline: A predetermined deadline should be set. Allow at least six weeks for the preparation of the paper. The submittal deadline for the written paper should be at least two weeks prior to the oral presentation.

Judging: The papers will be judged on the basis of engineering content, originality, interpretation of data, organization and written and oral presentation.

Engineering Problem Solving Competition

TECHNICAL PAPERS
Evaluation Form

Category _____

Title of Paper _____

_____

Author's Name _____

CRITERIA FOR EVALUTION

	Superior	Excellent	Good	Fair
Creative Approach				
Originality				
Knowledge of Subject				
Interpretation of Data				
Organization				
Written Presentation				
Oral Presentation				

Remarks _____

_____

_____

Award Classification

Superior	91 - 100 points
Excellent	81 - 90 points
Good	71 - 80 points
Satisfactory	61 - 70 points
No Designation	0 - 60 points

_____
Signature of Judge

Geothermal Energy

Geothermal energy extracted from areas having geothermal resources can be used for generating electric power, heating and cooling buildings, warm water agricultural irrrigation, industrial processing, etc. How can these resources best be utilized best?

Nuclear Energy

Nuclear energy was developed as the power-generating fuel of the future. Public opinion is forcing utility companies to reevaluate its feasibility. How safe is nuclear energy? Is there such a thing as unbiased data?

Alternate Energy Sources

Wind power generation, solar collection, shale oil, methane, waste materials, etc. are untapped on a large-scale basis. Why?

Efficient Utilization of Coal

In the past coal was the major energy and home heating source. Due to ecological reasons its use has been minimized despite an abundance of resources. What methods are being developed to convert coal into a clean-burning fuel?

Computer-Aided Graphics

Many television show titles and cinematic special effects are the product of computer-aided graphics. What is the engineer's role in their production?

Robotics

Manufacturing processes, in particular, have changed with the introduction of robotic devices and machinery. How does robotics work? Is it labor-saving? Is it cost effective?

Fiberoptics

The use of fiberoptics is rapidly becoming one of medical sciences most important tools. Fiberoptics are used in many of the exploratory procedures. How has fiberoptics revolutionized medical diagnostics?

Matching Technology to Society

Technology should serve man. Technology should fill a need; it should make life safer, easier, more pleasant. What are the major problems encountered when matching technology to society?

Traffic Flow

Traffic flow exists all around us. Measure the traffic density of the school cafeteria at various times. Construct a model of the traffic flow. Make recommendations for improved cafeteria service without increasing the costs.

Optimization

A queue is a waiting line. Major airports have queues for the take-off and landing of aircraft. Likewise there are queues at banks, college registration, the supermarket, toll booths and fast food counters. How can math modeling and optimization aid in the control of these queues?

Solid Waste Recycling

Six million automobiles are scrapped each year. Appliances are discarded, refuse from building construction/demolition is dumped, household and industrial trash--over 200 million tons per year are rendered useless. How can solid waste be recycled efficiently, economically and safely?

Year-round St. Lawrence Seaway

The St. Lawrence Seaway freezes in the winter months and does not permit passage. What methods could be developed to permit the Seaway to operate year-round? What impact on the environment, industry, etc.?

History of Engineering

What was engineering like 200 years ago? What changes in our way of life were the result of engineering advances over the past two centuries? What impact has it had on the environment, the economy, social norms and values?

Artificial Heart Implant

In this decade many biomedical milestones have been reached. One of the most significant and the one that has received the most media attention is the artificial heart. How was the artificial heart developed? What are the limitations of the design? How will it effect the future of heart medicine?

Other topics could be relative to:

- Information Systems
- Leonardo daVinci: Artist or Engineer?
- Probability Studies
- The 35mm Camera: Now and then
- Laser Applications
- Electronic Toys and Games
- Aspects of Integrated Circuitry
- Food Production
- Home Energy Consumption
- Engineering and Sports
- VCRs or Video Discs
- Microcomputer Applications
- Hydrofoil Sailboats
- Consequences of Photocopiers

See also the Discussion Ideas on page 40 of the Miniprojects section. In selecting a topic, keep in mind that engineering and technology has an impact on nearly every aspect of life. Do not limit yourself to the "tried and true".

Engineering Problem Solving Competition

The Problem Solving Competition deals in specific engineering problems and solutions and their pragmatic interactions with economic considerations. The solutions will be presented in the form of technical reports.

General

The purpose of the problem is to familiarize JETS members with the type of work performed in industry, to lead members through a typical industrial problem, and to stimulate their interest in engineering.

An engineering problem and its solution will be designed by a practicing engineer engaged by each of the participating chapters. Teams of JETS members will have the opportunity to develop the solution. The competition may be a JETS chapter activity, an intrachapter competition or an interchapter competition.

The problem should be a typical industry problem that demonstrates engineering and mathematical design and/or modeling, have workable solutions, involve and be dependent upon economic considerations. In addition, the importance of a good presentation of the solution should be emphasized. Competition rules appear on page 56 and The Engineering Design Method appear on page 46.

The Problem

An engineering problem which results in two or more alternate solutions is the most desirable type of problem. The problem can result in a specific answer or solution, but it is more desirable if the participants are required to make a judgment decision as to the best alternative. The participants then present and discuss their findings and make specific recommendations as to the most economical course of action.

In general, the length and complexity of the problem can be controlled by the background data given and number of calculations required. It may be necessary to modify the problem if the alternate solutions and cost comparisons prove too complex or lengthy. In this case, one or two alternate solutions may be given or one or more specific issues within the problem may be solved or given. See page 59 for a sample problem and solution. It is desirable to have several problems from which one will be chosen.

The Formats

Problem Format

1. Cover sheet
2. Background
3. Assignment
4. Problem information
5. General information
6. Suggestions for solution
7. Suggestions for presentation
8. References furnished with problem

Problem Solution Format

1. Cover sheet
2. Recommendation(s)
3. Conclusion(s)
4. Step-by-step outline of solution
5. Tables if required
6. Graphs if required
7. References

The Competition

Once the problems have been formulated, an announcement is sent to all the participating members or chapters stating the objective of the competition, the guidelines, the timetable, the engineering problems and copies of the competition rules and the Engineering Design Method.

Problem Assistance and Evaluation

Problems selected for distribution are submitted to the student chapters where a student team will select and solve a problem. During the problem solving period, participants may consult the problem author for clarification or limited assistance. It may be necessary to furnish additional information or references. It will be the responsibility of the author to evaluate the report before it is submitted to the judges for final competition.

Engineering Problem Solving Competition

To: JETS Chapters in the (locale) area

The (sponsoring JETS) Chapter announces its Engineering Problem Solving Competition for JETS Chapters in the (locale) area. The final competition will be (date) .

The objective of the competition is to provide JETS members with an opportunity to learn something about engineering from a practical standpoint. The competition will reflect the economic considerations as well as the technical aspects of engineering problem solving.

The rules governing the competition are enclosed. Please read them carefully. Also enclosed is a copy of the Engineering Design Method which may be used as a guideline to problem solving.

There are (number) problems from which your team may chose one. There is no restriction on the number of teams working on the same problem.

The problems have been authored by practicing engineers and represent what engineers may encounter in their work. Each of these problems have been reviewed by the competition committee. At first glance they may appear difficult, but they involve step-by-step procedures which can be understood and solved by students in the upper third of their high school class. The authors have supplied references which are considered necessary to the solution. It is advisable to contact the author as soon as possible after selecting the problem and before starting the project. He/she may be able to supply suggestions, assistance or additional information. The author will also review the report prior to official submission and will supply the judges with comments and recommendations as to the accuracy of the data, relevance of the solution, etc.

Pay particular attention to the timetable for the competition. Allow sufficient time for revisions or improvements to the report or presentation. It should be noted that a penalty of three points will be deducted if the solution is submitted less than one week prior to the competition date. The winning margin in a typical competition is usually only a few points and these penalty points can be important.

If an intrachapter competition precedes an interchapter competition, the judges may offer participants some general suggestions which may assist the presentation at the interchapter competition. The judges are not permitted to discuss the accuracy or validity of the solution or report.

Listed below are the individuals from the (Chapter) who may be contacted for further information or assistance. Good luck to each of you. Your efforts will be rewarded.

Chairman: (name)
Contact: (telephone numbers)

Members: (names)
Contact: (telephone numbers)

Engineering Problem Solving Competition

I. PROBLEMS

A. A panel consisting of members of the sponsoring JETS Organization Engineering Problem Solving Competition will screen problems submitted by authors.

B. Problems must include technical, economical and social considerations.

C. The difficulty level of the problems and their solutions must be for high school students in the upper third of their class.

D. The problem author must be accessible to the students for a reasonable amount of time during the problem-solving period to answer any questions that may arise or to give assistance or clarification. If the author is not accessible, the competition chairman should be notified. **Note**: It may be wise to set a particular time period during which the students may contact the author, so as not to interfere with employment protocol.

II. TEAM ENTRIES

A. A team will consist of three JETS members. If a third member cannot be obtained, special permission may be granted by the competition organizers for two JETS members to form a team.

B. Each team will present one problem and solution in competition.

C. Only one team from each JETS Chapter may participate in the area-wide (interchapter) competition.

D. If a JETS Chapter has more than one team participating, an intrachapter competition must be held to determine which team will represent that JETS Chapter in the interchapter competition.

E. The winning team in the intrachapter competition must present the same problem in the interchapter competition.

F. The team members may receive indirect help from teachers, engineers or other professionals while working on the problem. This help must be in the form of advice or suggestions **only**. No help from direct solutions or calculations will be allowed.

G. The technical report must be submitted to contest organizers one week prior to the presentation of the report before the judges. This applies to both intra- and interchapter competitions. A penalty of three points will be deducted from each judge's score for reports submitted less than one week prior to the competition deadline.

H. Competition organizers must be contacted when intrachapter competitions will be required. Two weeks notice should be given.

continued

III. CONTEST DEADLINES

A. Problem reports for intrachapter competitions must be submitted one week prior to competition date.

B. Intrachapter competitions must be completed at least two weeks prior to interchapter competitions.

C. Problem reports for interchapter competitions must be submitted one week prior to that competition.

D. Awards will be presented on the day of the competition.

IV. PRESENTATION

A. Written

1. The problem report is to be neatly presented with all pages and figures no larger than 8-1/2 x 11 inches.

2. The basic presentation should show calculations in a brief and logical sequence--clearly indicating the recommended solution and why it is recommended. Detailed calculations and data should be attached as appendices.

3. Outside sources (references)--books, paper, reports, etc., used in the development of the solution should be identified within the report.

B. Oral

1. Each team member is required to participate in the presentation.

2. Competition presentations will be limited to 15 minutes.

3. After the presentation, five minutes will be allowed for questions and answers.

4. The time limit for intrachapter compeition presentations may be shortened if competition officials approve.

5. Slides or overhead projectors may be used. Make the necessary arrangements with the contest officials.

V. JUDGING

A. Intrachapter competitions will be judged by a panel of three judges.

B. Interchapter competitions will be judged by a panel of five judges.

continued

V. JUDGING

C. The judges will take the point of view of management officials with minimal technical expertise who will determine what expenditure of funds will be given to the projects.

D. Judges for all Engineering Problem Solving Competitions will be selected by the JETS sponsoring chapter.

E. All presentations will be judged in the following categories:

1. Accuracy of calculations
2. Reason and logic used, thoroughness of investigation and research
3. Written presentation
4. Oral presentation

F. Each judge will award points to each team in the following categories:

First Three Categories (Problem Solution & Written Presentation)		Fourth Category (Oral Presentation)	
Excellent	10	Excellent	5
Good	8	Good	4
Average	6	Average	3
Fair	4	Fair	2
Poor	2	Poor	1

G. The winning team will be the team with the highest number of points after the individual judges have combined their scores.

H. Each judge will have a copy of the comments and recommendations of the problem author relative to the data, accuracy and technical expertise of the team s report.

VI. AWARDS

A. Awards will be presented to the first, second and third place teams. Awards can be individual awards to team members or one award for the team.

B. If the winner of an intrachapter receives an award in an interchapter competition, the intrachapter award will be given to the second place team.

C. Awards are the responsibility of the sponsoring chapter.

Engineering Problem Solving Competition

This sample is from an Engineering Problem Solving Competition of the Oklahoma City JETS Committee.

TITLE: "Gas Well Economics"

Engineering Discipline: Petroleum Engineering

Problem Number: 4

PROBLEM AUTHOR: (Name)

Company Affiliation: (Company name)

Mailing Address: (Company address)

Business/Home Phone: (Business and home numbers)

PROBLEM

The Sooner Oil Company has discovered a new gas field in Beaver County. The third producing well has just been completed at a depth of 9200 feet and tested. From the drilling to date, a company geologist has drawn the map shown which indicates the size of the field to be well defined at 2000 acres. The thickness of the producing reservoir in each well is shown on the map.

A contract has been signed with Oklahoma Natural Gas to sell the gas for $0.17 per thousand cubic feet (per MSCF) initially, increasing $0.01 per MCF every four years. (This is a typical gas contract.)

Problem Infomation

- Cost of each producing well (including cost to equip for gas sales): **$200,000.**
- Cost to operate each well: **$6,000/year**

Reservoir Data:

- Reservoir pressure, initial (pi): **3500 psia**
- Porosity (ϕ): **24 %**
- Connate Water (Sw): **35 %**
- Reservoir Temperature (T): **150 degree F (610 degree R)**
- Compressibility factor (Z) @ initial pressure (pi): **0.89**
- Compressibility factor (Z) @ abandonment pressure (pa): **0.95**
- Reservoir pressure, at abandonment: **800 psia**
- Productive area: **2,000 acres**
- Thickness of gas pay zone: **See map**

Production Rates and Times:

- With three wells, gas will be produced at equal yearly rates over a period of 24 years.
- With four wells, gas will be produced at equal yearly rates over a period of 20 years.
- With five wells, gas will be produced at equal yearly rates over a period of 16 years.
- Royalty = 12-1/2 percent of total revenue.

continued

As a company engineer, you are to estimate the amount of recoverable gas in the reservoir. Also, you are to determine if (and how many) more wells should be drilled to yield the maximum discounted operation profit. The present three wells will recover the gas reserves but additional wells can cause the production rate to be higher, thereby recovering the same amount of gas in a shorter period of time. Space requirements allow as many as five wells maximum.

Suggestions for Solution

From the pressure (p), temperature (T) and compressibility factor (Z) data, calculate the gas volume factor for the reservoir at initial conditions and abandonment conditions (Bgi and Bga respectively) (see page 24 of Craft and Hawkins). Then calculate the unit recovery using the porosity (ϕ), connate water (Sw) and gas volume factors above (see page 34 Craft and Hawkins).

Estimate the productive reservoir volume by averaging the thickness of the sand in the three wells and multiplying by the area of the reservoir. Then obtain the total recoverable gas by multiplying the productive reservoir volume by the unit recovery.

The economic feasibility of additional drilling should be determined by calculating the discounted operating profit for a three-well field, a four-well field and a five-well field. A comparison of the results will indicate the feasibility of additional drilling.

Suggestions for Presentation

The map of the gas field should be displayed, showing the location of the present wells and pointing out the limits of the reservoir and thickness of the gas pay zone at each location. The amount of recoverable gas should be discussed--perhaps pointing out the important reservoir parameters such as pressure, porosity, and connate water.

This economic presentation should show the anticipated revenue, operating costs, discount factor, cost of producing wells, and finally the discounted operating profit presented for three, four and five wells. Of course, the final recommendations should be based on a comparison of the discounted operating profit for each of the above.

Reference

Craft and Hawkins, Applied Petroleum Reservoir Engineering, Prentice Hall, New York, NY, 1959.

Production Rate and Times
Severance Tax = 5 percent of the gross value

Discount Factor (Using 10 percent discount rate)
Constant production 16 years = 0.499
Constant production 20 years = 0.432
Constant production 24 years = 0.379
For gas price use arithmetic average for the life of the well.

continued

General Information

Discounted operating profit: Remaining profit after revenue from gas sales is reduced by royalty, severance tax and operating cost, then multiplied by the proper discount factor. The cost of the wells drilled (undiscounted) is then subtracted to yield discounted operating profit.

Porosity (ϕ): Void or pore space between the sand grains in which the reservoir fluids (gas and water in this problem) are contained.

Connate Water (Sw): Water contained in the pore space along with gas and/or oil in a productive reservoir. The space occupied by water reduces the available space for gas or oil.

Compressibility Factor (Z): Gas deviation factor which is a number representing the amount the gas deviates from perfect behavior (or perfect gas laws).

SCF (Standard Cubic Foot): This is a cubic foot of gas at standard conditions (or 14.7 psia and 60 degree F). All gas volumes are related to this quantity.

MSCF (One thousand Standard Cubic Feet): This is usually the basic quantity used for the price in a gas contract. (In this problem the price is $0.17 per MSCF.)

MMSCF: One million Standard Cubic Feet

MMMSCF: One billion Standard Cubic Feet

Royalty: Fraction of total revenue paid by the lessee (Sooner Oil Company) to the lessor (landowner).

Severance Tax: Fraction of the revenue paid to Oklahoma as tax.

Original Bgi = $35.35 \left(\frac{3500}{.89 \times 610}\right)$ = 228 SCF/CF

Abandonment Bga = $35.35 \left(\frac{800}{.95 \times 610}\right)$ = 49 SCF/CF

Unit Recovery

= 43.560 x ϕ x (1-Sw) x (Bgi-Bga) SCF/AF

= 43.560 x .24 x (1-.35) x (228-49) = 1,216 MCF/AF

Total Recoverable Gas

= 10 x 2,000 AC x 1,216 MCF/AF

= 24,320 MMCF

Average Gas Price

16 years	$0.19/MCF
20 years	$0.19.5/MCF
24 years	$0.20/MCF

Three Wells

Revenue 24.32 MMMCF ($200,000 - $10,000) x .875 =	$4,043,000
Operating Cost $18,000/year x 24 years =	-432,000
	$3,611,000
	x0.379
	$1,369,000
Drilling Cost $200,000 x 3 wells =	-600,000
Discounted Operating Profit	$ 769,000

Four Wells

Revenue 24.32 MMMCF ($195,000 - $9,750) x .875	$3,942,000
Operating Cost $24,000/year x 20 years =	-480,000
	$3,462,000
	x0.432
	$1,496,000
Drilling Cost $200,000 x 4 wells =	-800,000
Discounted Operating Profit	$ 696,000

Five Wells

Revenue 24.32 MMMCF (190,000 - $9,500) x .875 =	$3,841,000
Operating Cost $30,000/year x 16 years =	-480,000
	$3,361,000
	x0.481
	$1,617,000
Drilling Cost $200,000 x 5 wells =	-1,000,000
Discounted Operating Profit	$ 617,000

CONCLUSION

A comparison of the discounted operating profit is as follows:

three wells	$769,000
four wells	$696,000
five wells	$617,000

This shows that more profit is obtained by present three producing wells and additional drilling will result in a reduced profit.

RECOMMENDATION

No additional wells should be drilled.

Engineering Problem Solving Competition

COMPUTER PROBLEM SOLVING
Wilson Magnet School of Science
and Technology, Rochester, NY

The Computer Problem Solving Competition is based on a computer problem solving competition sponsored by the Rochester (NY) Area Schools Computer Activity League (RASCAL). Gary Walker and Mike Michalek adapted it from an article in **Creative Computing** (October 1983) about a competition generated by the University of Wisconsin-Parkside.

Teams of two to four students each will compete in a microcomputer lab venue to solve two of three computer programming problems using BASIC in a timed period.

Competition Format

A team of two to four participants will compete in one of two divisions: Junior - Grades 7-9 and Senior - Grades 10-12. Three problems are generated and participants will have 45 minutes to write a program for two of the problems. Completed programs are then rated by two judges--volunteers from the computing faculty of the competing schools. Judging is kept impartial by the use of a number system that identifies the teams.

Problems and Scoring

The problems should be designed by the faculty of the sponsoring school. They should be designed so that one is relatively easy, the second of moderate difficulty and the third relatively difficult. Participants are encouraged to use the REMark statements to identify all variables and to lead into subroutines.

Each problem solution program should be graded on a 20-point basis. If the solution is correct, the team receives 15 points. Up to five points can be awarded for technique and creativity. Problems are weighted based on difficulty. The weighting by difficulty is used as a multiplication factor to determine the winner.

Awards

Trophies, certificates or prizes should be awarded to the top three teams in each division. A traveling trophy may be purchased for an area-wide competition that may be held annually or periodically.

Sample Problems

SENIOR DIVISION:

Hardy's Taxi

G. H. Hardy, a famous British mathematician, told a young Indian mathematician named Ramanujan that he had just ridden in a taxi cab with a number that was very dull. Ramanujan promptly replied that it was an interesting number. He claimed the number to be the smallest integer that could be expressed as the sum of two cubes TWO DIFFERENT WAYS. What was the number of that cab?

continued

Hexadecimal Values
Write a program that will convert any decimal value from 0 to 255 into a corresponding two-place hexadecimal value.

```
Example:   Decimal number?  255
           Hex representation:  FF

Test for:  5   11   72   136   254
```

Did You Get the Number of That ...?
Write a program to accept as input the following paragraph and to print the frequencies of ocurrence of each letter of the alphabet and the space:

> Now is the time for all good men to come to the aid of their country. These are the times that try people's souls. Tis a far, far better thing I do than.... The euphony of xylophones is unmatched!

JUNIOR DIVISION:

In a Word--Binary Revisited
Write a program to accept any integer from -32767 to +32767. Represent the number as a 16-bit binary word where the left-most bit represents the sign (1 if negative and 0 if positive). The right 15 bits will be the binary representation of the magnitude of the number input.

```
Example:  What is the decimal value? -255
          The binary word for -255 is:
          1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1

Test for: -32767
          +32767
          82
          -17384
          +32700
          -12222
```

Pattern Outline
Using an * in your program only twice, write a program to accept the length and the width of a rectangle. Print the pattern as below:

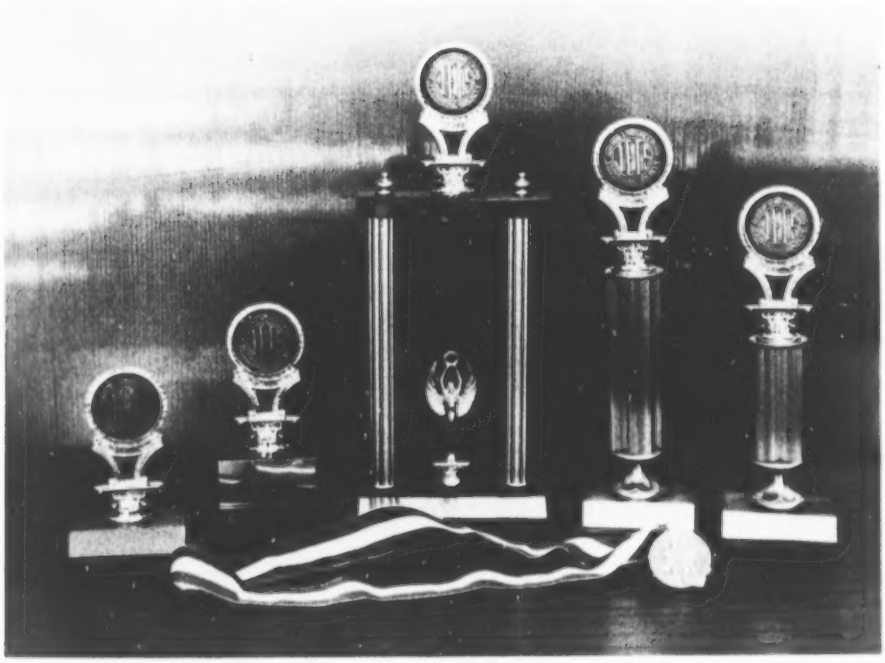
```
Width? 7                Test for:  Width = 17          Length = 10
Length? 12                         Width = 5           Length = 12
                                   Width = 25          Length = 25
```

Word Play is Child's Play
Write a program to print only the vowels of any input string.

```
Example:   String?  Simple Simon
           Vowels:  I E I O
```

Test for each of the following strings:

- rapidamente
- abstemiously
- facetiously
- supercalifragilisticexpialidocious
- jets competitions are fun -- I think?!



Awards are available from JETS. For prices write 345 East 47th ST., New York, NY 10017.

JETS objectives are:

- To assist precollege level students in learning about realistic opportunities in engineering, technology, and science and to advise them of educational requirements and schlorship opportunities at the high school and college level.
- To encourage students to excel in their studies and to emphasize college preparatory courses in mathematics, science, and communication skills.
- To help students relate engineering, science, and mathematics to the real world and to aquaint with applications within a free enterprise system.
- To accomplish the foregoing through school-sponsored clubs; local, state and national competitions; publications; and other career-related educational activities.
- To provide leadership training through student officer responsibility.

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